RECORDS OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1910. [August.

# PRE-CARBONIFEROUS LIFE-PROVINCES. BY F. R. COWPER REED, M.A., F.G.S.

## INTRODUCTION.

THE problems of the geographical distribution of life in the Palæozoic seas are continually being brought nearer satisfactory solution by the detailed palæontological study of the ancient deposits in distant lands; and during the last few years a considerable mass of new facts has been accumulated which require some of our existing conceptions to be modified. A survey of the current views on the subject is therefore desirable. This revision is particularly requisite in connection with the continent of Asia, where investigations have been rapidly proceeding with remarkable results. By the concurrent advance in our knowledge of the principles which guide the correlation of formations and the migrations of faunas (**1**), of the dependence of organisms on their environment, of the value of isolation as a factor in evolution (**2, 3**), of the relative importance of various physical factors, and of the distinction of the several biological elements in a fauna, we are now better enabled to approach the questions connected with the past distribution of organisms.

It is no longer possible to maintain that the diffusion of Lower Palæozoic life was uniform; there is no such thing as a universal fauna during any geological period; differences in composition or character, of greater or less degree, are always apparent, even when dealing with the faunas of deposits which were formed in the same marine basin and under similar conditions, so far as their lithological character indicates. On the other hand heterochronous faunas are found to be similar

in distant regions; and heterochthonous faunas (4), not in genetic series with their immediate predecessors, introduce a new problem. While special types of faunas are recognised to be frequently restricted to limited areas, widely diffused organic assemblages also occur and are regarded as evidence of free intercommunication in the seas and of the absence of effective barriers. The effects of the immediate physical environment are sought for in special local adaptations amongst members of the fauna, apart from a general progress in organic evolution which is acknowledged to be traceable from period to period, though not at a uniform rate in all parts of the world or with precisely the same features under all conditions.

A zoo-geographical student pays special attention to localised or provincial types of faunas, and in seeking to apply the lessons of present marine distribution to the problems of the past, it is necessary to discriminate between the various elements in the fauna grouped according to their presumed mode of life, their autochthonous or heterochthonous ancestry, their adaptation to peculiar local conditions, and their connection with the nature of the sedimentation, and to separate the restricted from the widely-distributed or cosmopolitan members. When such a preliminary classification has been made, the strength and character of the local or provincial elements become apparent.

A primary difficulty which confronts us is our frequent ignorance of the mode of life of some important groups or families or genera amongst the Palæozoic faunas. We have to trust for help in these cases not only to the evidence of the general structure of the organisms and to the analogy of allied or similarly built living types, but also to their mode of occurrence, their association with other organisms, the nature of the sediment in which their remains occur and the individual peculiarities of the fossils, such as their state of preservation, frequency, local abundance, etc. A case in point is that of the trilobites; but, as with modern crustacea, it is probable that in such a large and varied group there were shallow water forms, deep water forms, and open sea forms, some inhabiting clear and others frequenting muddy waters, while we cannot doubt that they differed in their powers of locomotion and migration (4a).

When we have satisfied ourselves that the fauna of the beds of any particular age and area is of a local or provincial type with marked peculiarities in composition and character, such as the presence of local genera or species, we have to seek to discover the

previous paper, yet the absence of anything approaching a definite anticline in them precludes much hope of obtaining oil, save in shallow wells. There is plenty of evidence that oil could be obtained in shallow Burmese wells, but the water level of the country seems to be too high to obtain oil at a depth by boring.

A few years ago many wells were drilled around Banbyin and Padaukpin, but they have all been abandoned, and I do not think that the locality offers any inducement for further experimental drilling.

# FOSSIL FISH TEETH FROM THE PEGU SYSTEM, BURMA.

BY MURRAY STUART, B. SC., F.G.S., *Geological Survey of India.* (With Plates 25 to 27.)

## Prome District.

THE following teeth were obtained by me this year from a bed near the base of the Lower Prome series opposite Prome, situated on the bank of the Irrawaddy just below the Sinde Bungalow :—

*Carcharias* (*Aprionodon*) sp.—These teeth, which are very numerous in this bed, resemble very closely the species *Carcharias* (*Aprionodon*) *frequens* Dames, found in the Eocene of Egypt,[1] but differ in having the vertical furrow in the base less distinctly marked (Pl. 25, fig. 1-3).

*Carcharias* (*Prionodon*) sp.—The two teeth figured here (Pl. 25, fig. 4) belong to the genus *Carcharias* and to the sub-genus *Prionodon.* They resemble somewhat the teeth of *Carcharias* (*Prionodon*) *gangeticus* Müller and Henle, but are much smaller.

*Galeocerdo latidens* Ag.—This species is of frequent occurrence in this bed. The tooth figured is a broken specimen of a lateral tooth. It resembles exactly a fossil found in the Province of Moçambique.[2] Several other teeth of this species were found, but they broke into fragments while being extracted from the sandstone (Pl. 25, fig. 5). The presence of *Galeocerdo latidens* in these rocks indicates an Eocene or Oligocene age,[3] while the teeth which I have referred to the genus *Carcharias* (*Aprionodon*), from their similarity to *Carcharias* (*Aprionodon*) *frequens*, seem to indicate a similar age.

Since I have shown in a previous paper that these teeth occur in a bed some 3,000 feet below the bed containing *Ostrea latimarginata* Vred.[4] (which is at latest lowest Burdigalian), the evidence of age given by these teeth conforms perfectly with the view that these beds are at latest Oligocene.

[1] F. Priem : Sur les Poissons fossiles éocènes d'Egypte et de Roumanie (*Bull. Soc. géol. de France*, 3e série, t. XXVII, 1899, p. 243-244, pl. II, fig. 8-15).

[2] F. Priem : Poissons tertiaries des possessions Africaines du Portugal. (*Comm. da Commissao do Servico geologico de Portugal*, Tom. VII, Fasc. I.)

[3] F. Priem : *l. c.* p. 79.

[4] *Supra*, p. 274.

## Padaukpin and Banbyin in the Thayetmyo District.

*Carcharodon megalodon* Ag.—This specimen (Pl. 25, fig. 6) was obtained by Dr. Noetling from the Pegu shales at Padaukpin and is described by him in his monograph.[1] As the original lithograph in the monograph is somewhat indistinct, I have refigured the specimen from a photograph.

*Hemipristis serra* Ag.—These teeth are very common throughout the shales around Padaukpin and Banbyin. It is a species characteristic of Miocene and Pliocene age [2] (Pl. 25, figs. 7 and 8).

The presence of these two forms indicates a Miocene or Pliocene age [2] and thus confirms the view given by me in the preceding paper that these rocks are the upper development of the Kama clays. These two forms, together with the form referred to *Lucina globulosa*, which was found by Mr. Dalton in these shales [3], definitely indicate that their age is Middle Miocene. *Hemipristis serra*, owing to its abundance, will probably prove of great importance in proving the presence of equivalents of the Kama clays at localities far apart from each other.

## Minbu and Yenangyat Oilfields.

*Lamna spallanzanii* Bonaparte (Pl. 25, figs. 9 and 10). This form was obtained by Noetling from the above-mentioned oilfields and is figured and described by him in his memoir.[4] It is synonymous with the forms *Oxyrhina spallanzanii* Bonaparte, and *Oxyrhina gomphodon* Müller and Henle, and has hitherto been found to have a range extending over Pliocene and recent times.[5]

The existence of this form in the faunas of these three oilfields indicates that the rocks in which it occurs are at least high in the Miocene, if not actually in the Pliocene, thus corroborating the view put forward by me in the preceding paper that the rocks of these fields are of later age than the zone of *Arca theobaldi* (base of the Kama clays).

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1 F. Noetling: *Pal. Indica*, New Series, Vol. I, pt. 3, p. 374, pl. XXV, fig. 8.
2 Priem: *l. c.* p. 79.
3 *Quart. Journ. Geol. Soc.*, Vol. LXIV, pt. 4.
4 F. Noetling: *Palæontologia Ind.*, New Series, Vol I, pt. 3, p. 28-36, pl. XXV, figs. 4, 5, 6.
5 C. R. Eastman: *Palæontographica*, XLI. 1894. p. 189-191.

## Pakokku District.

*Carcharodon megalotis* Agassiz. (Pl. 25, fig. 2).—This form was found by Mr. G. de P. Cotter in the stream (Dandin chaung), north of Nyaungbinzauk (21° 42', 81° 42') in beds which he identifies as the basal beds of the Irrawaddy series (Fossil-wood series of Theobald).

*Otodus appendiculatus* Agassiz.—To this species I have referred a form obtained by Mr. Cotter (Pl. 25, fig. 11) from beds occurring near Myaing which he assigns to the Pegu system. It is a form which is abundant in the Cretaceous system in England and on the Continent.[1]

## Singu Oilfield.

The fossil fish teeth which I describe below were, with one exception, obtained from the Pegu beds exposed in the Singu Oil-field, by Mr. S. Sethu Rama Rau, in the season 1907-08. They contain several forms which have hitherto not been found in Burma.

*Oxyrhina spallanzanii* Bonaparte.—These teeth were found in abundance in two fossil zones, situated low in the field, some considerable distance below the zone of *Meiocardia metavulgaris*, described by Noetling. As I have already shown these teeth are thought to range over Pliocene and recent times.[2] In his memoir on the Fauna of the Miocene beds of Burma, Noetling describes this form as occurring in both the zones, *Mytilus nicobaricus* and *Meiocardia metavulgaris*, but the specimens figured by him come from another district, Minbu[3].

*Carcharodon lanceolatus* Agassiz.—The species described by Agassiz under the above name is characterised by its slender shape, and also, equally, by the existence at the base of the enamel of two distinct grooves. The figured specimen, which was found in the zone of *Meiocardia metavulgaris*, is not quite so slender in shape as the one figured by Agassiz, but the presence of the two

1 Agassiz: *Poissons Fossiles*, pt. III, p. 270. Compare also Theobald's views as to the very Cretaceous aspect of many squaline teeth from the Pegu system (*Memoirs, Geol. Surv. India,* Vol. X, pt. 3, p. 87).

2 *Supra*, p. 293 : also C. R. Eastman : *Beiträge zur. Kenntniss der Genus Oxyrhina—Palæontographica*, XLI, (1894), *Stuttgart*, pp. 190 and 191.

3 *Pal. Ind., New Series*. Vol. I, pt. 3, p. 32, 33, pl. XXV, figs. 4, 5, 6.

distinct grooves at the base of the enamel on the front of the tooth suffices to assign it definitely to this species. The form described by Agassiz came from the Eocene at Kressenberg.

*Carcharias* (*Aprionodon*) *frequens* Dames.—*Sitzungab. k. preuss. Akad. Wiss.*, 1883, pt. 1, p. 143, Pl. 3, fig. 7. This species is characterised by the breadth of the root, which is at least double that of the height of the tooth, and also by the existence of a distinct vertical furrow situated in the middle of the inner face of the root. Some eight specimens of this species, three of which are figured (Pl. 26, figs. 5, 6 and 7), were obtained from a bed situated between the zones of *Mytilus nicobaricus* and *Meiocardia metavulgaris*.

*Carcharias* (*Prionodon*) *egertoni* Agassiz.—

Syn. *Carcharias minor* Ag. in Egert. catal.
*Corax egertoni* Agassiz, 1843, Poiss. Foss., Vol. III, p. 228, Pl. XXXVI, figs. 6 and 7.

This species is described as follows:—"Upper teeth broad, triangular, prominently serrated, both margins slightly concave. Lower teeth probably narrower than the upper, robust and prominently serrated." The specimens obtained by Mr. S. Sethu Rama Rau come from the zone of *Meiocardia metavulgaris* and from two higher zones situated between it and the zone of *Mytilus nicobaricus*, the uppermost of these intermediate zones being the one from which he obtained the species.

*Carcharias* (*Aprionodon*) *frequens* Dames.—The specimens obtained resemble very much the one figured in "Geological Survey of Maryland, Miocene plates," as coming from the Miocene system[1]. (Pl. 26, figs. 8, 9). From its similarity to the above form I have included the specimen shown on fig. 10 in this species. It differs from the others which I have figured, in that the length of the crown on the inner face of the tooth is less, and the height of the root greater; the front face of the tooth is however identical with that of the typical *Carcharias* (*Prionodon*) *egertoni*. Since Mr. S. Sethu Rama Rau obtained abundant specimens belonging to both these forms and also several specimens which are intermediate between the two, I have no hesitation in referring them all to the same species.

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[1] *Maryland Geol. Surv., Miocene plates*, Pl. XXXII, fig. 1.

*Carcharias* (*Prionodon*) *collata* (ex. Cope MS).—This species is described first in "Geological Survey of Maryland, Miocene text," as :—"A species of moderate size, the teeth comparatively stout, with a narrow, usually erect crown, strongly convex on its inner and slightly so on its outer face ; apex sometimes curved slightly inwards or backwards ; coronal edges with extremely minute serrations disappearing towards the base. The enamel at the base of crown extends much lower down in the middle of the outer than on the inner face. The root is considerably elongated, large and symmetrical."[1] Only one specimen (Pl. 26, fig. 12) of this species was obtained ; it was found in the bed that yielded the specimens of *Carcharias* (*Aprionodon*) *frequens*. This form occurs in the Miocene of Maryland and specimens are preserved in the collections of the Maryland Geological Survey and the Philadelphia Academy of Natural Sciences.

*Hemipristis simplex, n. sp.* (?).—I have figured under this name a specimen obtained from the above-mentioned bed that yielded *Carcharias* (*Aprionodon*) *frequens* Dames, *Carcharias* (*Prionodon*) *egertoni* Ag., and *Carcharias* (*Prionodon*) *collata* (ex Cope M.S.) It resembles strongly *Hemipristis serra* Ag., differing in the entire absence of any indications of serration along the marginal edges of the tooth. It is stout and narrow, convex on both faces, about 2 cms. in height measuring from the apex to the base of the enamel. The lateral edges of the crown are sharp from the apex to a point level with the top of the swelling on the inner face of the root, below which the crown is rounded. The swelling on the inner face of the root bears a deep longitudinal notch, resembling *Hemipristis serra* in this.

Two specimens only were obtained ; the one which I figure (Pl. 26, fig. 13), and another specimen, the uppermost portion of whose crown was missing. Consequently I had a vertical section cut of the less perfect specimen, and the microscopical examination (Pl. 27, fig. 1) confirmed my view that this specimen must be classed with the genus *Hemipristis* Agassiz. Since the specimen figured is in very good preservation and shows no sign of having been worn, it cannot very well be classed as *Hemipristis serra*, which it most resembles in form, because one of the distinguishing characteristics of *Hemipristis serra* is the form and size of the

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[1] *L.c.* p. 85, Plate XXXII, figs. 3 to 5.

serrations along its lateral margins. In 1878, Probst described and figured as *Hemipristis serra* a very inclined tooth which is also destitute of all marginal serrations (*Württ. Jahresh.*, Vol. XXXIV, p. 143, pl. 1, fig. 50); but there is this difference between it and the one described above, that the sharp edge which runs downwards from the point in one piece, does not fall or cease in the specimen described by him, whereas it does cease some distance above the root in the specimen described by me. Another reason which makes me unwilling to refer this tooth to the species *Hemipristis serra* is that it is an almost erect specimen and therefore probably an anterior tooth, and the anterior teeth of *Hemipristis serra* Ag. have strongly marked serrations on both marginal edges. I have therefore named it provisionally *Hemipristis simplex,* until some more specimens may be obtained and further light thrown on the subject.

*Hemipristis serra* Agassiz.—Two broken specimens of lateral teeth were obtained from the bed which yielded the previously described specimen of *Hemipristis simplex*, and another specimen of a lateral tooth and a broken specimen of an anterior tooth were obtained from the zone of *Meiocardia metavulgaris.* The specimen figured is from the latter zone (Pl. 26, fig. 14). The specimens of *Hemipristis serra* previously obtained from Burma by Dr. Noetling and myself were all obtained from the Padaukpin area, Thayetmyo, and have been discussed by me above.

*Sphyrna prisca* Agassiz ?—

Syn. *Carcharias gangeticus M. & H.*, F. Noetling: Fauna of the Miocene of Burma, *Pal. Ind.*, New Series, Vol. I, p. 375, Pl. XXV, figs. 11-15.

No specimens of this species were found by Mr. S. Sethu Rama Rau. I have examined the specimens which were referred by Noetling to the species *Carcharias gangeticus* M. & H., and, on comparison with the sets of teeth of this species which are preserved in the Indian Museum, I cannot confirm his identification. Noetling's specimens are considerably smaller than the teeth of a full grown *Carcharias gangeticus*, and even if it is possible that all his specimens come from half grown or smaller fish, which is not at all likely, since he obtained more than three dozen specimens, there is even then a distinct difference between his specimens, among which are some quite indistinguishable from the typical *Aprionodon*, and the teeth of *Carcharias gangeticus*. Noetling's specimens

are more slender and have their marginal serrations less distinct and less uniform and their anterior margin more concave than is the case in the species *Carcharias gangeticus*. His specimens correspond more closely with the species *Sphyrna prisca* Ag., the forms figured by him in figs. 12 and 13 resembling very closely the form figured by Agassiz on Tab. 26a, (Vol. III), fig. 35, while the forms figured by Noetling in figs. 14 and 15 resemble the form figured by Agassiz as *Sphyrna lata*; the latter, however, is looked upon as a very doubtful species. As it is exceedingly difficult to distinguish the genus *Sphyrna* Rafinesque from *Carcharias* by means of isolated teeth, it is possible that Noetling's specimens should be referred to some species of this latter genus, but they cannot be regarded as belonging to the species *Carcharias gangeticus* M. & H.; whether, in any case, they represent a living form cannot be decided until the investigation of the sharks of the Bay of Bengal, at present being conducted, is complete.

The presence of the forms *Oxyrhina spallanzanii* Bon., *Hemipristis serra* Ag., *Carcharias* (*Prionodon*) *egertoni* Ag., *Carcharias* (*Prionodon*) *collata* (ex. Cope MS.), indicates a Miocene age for these rocks in the Singu oilfield and therefore an age not older than the Kama clays, a view which has already been advanced by me from stratigraphical reasons, and which has already received some support from Noetling's reported discovery of *Oxyrhina spallanzanii* Bonaparte, in both the zones *Mytilus nicobaricus* and *Meiocardia metavulgaris*.[1]

## Pagan Hills.

In addition to the above described forms I have recently had sent to me for determination the following form from the geological collection of the Burma Oil Co. at Yenangyaung. It was obtained by Mr. Macrorie from one of the lowest beds exposed in the Pagán Hills.

The Pagán Hills are situated about twelve miles north-east of the Singu anticline and are reported by Mr. E. Grimes to consist of beds of the Pegu system of which neither the top or bottom beds are exposed.[2]

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1 *Supra*, page 288.

2 Grimes, G. E.: Geology of parts of the Myingyan, Magwe and Pakokku districts—*Memoirs, Geol. Surv. Ind.*, XXXVIII, p. 66.

*Carcharodon angustidens* Agassiz.—The species is described by Agassiz as follows: "It is distinguished from most other forms of *Carcharodon* by its very slender shape. Its shape is that of an isosceles triangle, and seen in profile from the side view it is practically vertical. Its thickness decreases insensibly towards the apex. The external face shows a slight longitudinal ridge which extends to the apex. Towards the lateral margins the same face is depressed, which gives it an appearance of being undulated. The inner face is convex. The marginal serrations of the enamel are distinct and uniform. The angle formed by the '*bourrelets lateraux*' and the principal cone is acute whereas the angle in other species, and notably in *Carcharodon auriculatus* is a very open angle."

The specimen figured (Pl. 26, fig. 3) is very similar to the form figured by Agassiz on Tab. 30, fig. 3, under the name *Carcharodon lanceolatus*, but which he afterwards referred to this species (Poiss. Foss., Vol. III, p. 255). The specimen figured by me however has sufficient of the root and '*bourrelet lateral*' preserved to prevent any confusion between the two forms.

A. Smith Woodward, in his catalogue of the fossil fishes in the British Museum (1889), classes, amongst other forms, the *C. angustidens*, *C. lanceolatus*, and *C. megalotis* described by Agassiz, as synonymous with *Carcharodon auriculatus* Blainville [1]; but Maurice Leriche, in his paper on 'Les Poissons éocènes de la Belgique', published in 1905 [2], disagrees with the synonymy suggested by A. Smith Woodward and takes away from the list of forms which he published as being synonymous with *Carcharodon auriculatus* Blainville, the following:—

*Carcharodon angustidens* Agassiz.
*Carcharodon turgidus* ,,
*Carcharodon lanceolatus* ,,
*Carcharodon megalotis* ,,

Since there is a majority of opinion against the synonym suggested by A. Smith Woodward, I have described the forms *C. angustidens* Agassiz, *C. lanceolatus* Agassiz, and *C. megalotis* Agassiz, as three separate species, rather than classing them all as C. *auriculatus* Blainville, feeling that, owing to the uncertainty

[1] *L.c.* page 412.
[2] M. Leriche: 'Les Poissons éocènes de la Belgique,' *Mem. Mus. Roy. Hist. Nat. de Belgique*, III, 1905.

which prevails, I cannot add confusion by so doing if the synonymy suggested by A. Smith Woodward is at any future time established; whereas if I class these three forms as *C. auriculatus* and the synonymy suggested by A. Smith Woodward is ever conclusively contradicted, I should have only added confusion and left it necessary for them to be redetermined.

The type form *C. angustidens* described by Agassiz comes from the Eocene of Kressenberg, though not from the same bed as the type specimen of *C. lanceolatus* Agassiz.

## EXPLANATION OF PLATES.

### PLATE 25.

*Figs.* 1, 2, 3.—*Carcharias* (*Aprionodon*) sp., natural size.
*Fig.* 3*a*.—Same twice, twice natural size.
„ 4.—*Carcharias* (*Prionodon*) sp., natural size.
„ 5.—*Galeocerdo latidens* Agassiz, natural size.
„ 6.—*Carcharodon megalodon* Agassiz, natural size.
*Figs.* 7, 8.—*Hemipristis serra* Agassiz, natural size (Padaukpin).
*Fig.* 9.—*Oxyrhina spallanzanii* Bonaparte, natural size (Minbu).
„ 9*a*.—Same tooth, back view.
„ 10.—*Oxyrhina spallanzanii* Bonaparte, natural size (Minbu).
„ 10*a*.—Same tooth, back view.
„ 11.—*Otodus appendiculatus* Agassiz, natural size.
„ 11*a*.—Same tooth, back view.
„ 12.—*Carcharodon megalotis* Agassiz, natural size.
„ 12*a*.—Same tooth, back view.

### PLATE 26.

Teeth from Singu Oilfield and Pagan Hills.

*Figs.* 1, 2.—*Oxyrhina spallanzanii* Bonaparte.
*Fig.* 3.—*Carcharodon angustidens* Agassiz.
„ 3*a*.— „ „ Agassiz (inner face)
„ 3*b*.— „ „ „ (side view).
„ 4.—*Carcharodon lanceolatus* Agassiz.
„ 4*a*.— „ „ „ (inner face).
„ 4*b*.— „ „ „ (side view).
*Figs.* 5, 6, 7.—*Carcharias* (*Aprionodon*) *frequens*, Dames.
*Fig.* 8.—*Carcharias* (*Prionodon*) *egertoni*, Agassiz (inner face).
„ 8*a*.— „ „ „ „ (outer face).
*Figs.* 9, 10, 11.—*Carcharias* (*Prionodon*) *egertoni*, Agassiz (inner face)

*Fig.* 12.—*Carcharias* (*Prionodon*) *collata* (ex Cope MS.
" 12*a*. " " " " (inner face).
" 13.—*Hemipristis simplex*, n. sp. (?).
" 13*a*.— " " " (inner face).
" 13*b*.— " " " (side view).
" 14.—*Hemipristis serra*, Agassiz.

## PLATE 27.

Vertical section of *Hemipristis simplex*, magnified sixteen diameters.

# THE NORTHERN PART OF THE YENANGYAT OILFIELD.

BY G. DE P. COTTER, B.A. (DUB.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 28, 29 and 29a.)

MY visit to the Yenangyat Oilfield took place in March and April 1908. Since the field has already been mapped by Grimes,[1] as far as the northern limits of Blocks 1 and 2, this paper will deal chiefly with the portion of the field which lies north of these blocks.

As far north as Block 134, the Yenangyat Hills rise sharply from the plain, forming a steep scarp along their eastern flank. To the north of this block, the hills sink gradually and the surrounding country rises to meet them, so that the range becomes indistinct and eventually dies out. The whole area is waterless, uninhabited, and covered with a thin jungle.

**Pegu Beds.**

The Pegu series, or as it has been termed by Grimes, the Miocene outcrop, extends as far north as Thangyi Daung (lat. 21° 22′ 40″ N.; long. 94° 43′ 21″ E.), where its topmost bed, the White Sand, can be seen exposed on the anticlinal crest in stream-beds to the north of the hill, and running from thence southwards on both sides of the hill, to form the western and eastern boundaries of the outcrop. This bed, the brilliant colour of which is due to the presence of kaolin, being considerably softer than the rocks above and below, is usually exposed in deep stream-beds coincident with the strike of the rocks, and attains a considerable thickness in the northern part of the field, being overlain, as at Yenangyaung and Singu, by a Red Earth bed, which changes frequently to a red conglomerate with white quartzite pebbles.

South of Yenangyat village, specimens of *Cyrena kodaungensis* Noetl., and a species of *Melania* have been collected from this bed by Mr. Sethu Rama Rao, and in the north of the field I have found in it abundant vertebrate remains, chiefly crocodilian.

The exact similarity of the White Sand bed, and also of the red bed above it, to those of Yenangyaung shows that they are of the same horizon, and we may therefore regard the White Sand as the topmost bed of the Pegu series.

[1] *Mem., Geol. Surv. Ind.*, XXVII, p. 30.

The White Sand bed in the northern part of Yenangyat, is underlain by a series of beds between three and four hundred feet thick, to which no corresponding types are found at Yenangyaung. These beds are a series of current-bedded buff sandstones with ferruginous conglomeratic earthy bands, and are characterised by a great abundance of silicified wood, as well as of selenite; this zone is more or less fluviatile, and is developed all along the western side of the anticline: on the eastern boundary, it can be traced from Thangyi Daung to Block 134, but is missing south of this block, as well as a large and varying thickness of beds beneath it, the greatest thickness of beds being absent at Yenangyat village, where, according to Grimes, a thickness of only 500 ft. of Pegu beds is found east of the crest.

While this fluviatile zone of beds containing both fossil wood and selenite is missing south of Block 134, isolated patches of the red bed and White Sand which overlie it, are found at several localities along the eastern boundary as far south as Block 60. To the south of this block there is no trace of either red bed, White Sand, or of the underlying fluviatile zone.

The eastern boundary of the Pegu series is therefore a very peculiar one, and will be discussed later. With regard to the beds underlying the fluviatile zone above described, it may be remarked that the upper part is poor in fossils and more or less estuarine, while the lower zones near the crest are of a marine type and yield a rich fauna. The Pegu series in this field may be divided as follows:—

*Zone 1.*—White Sand bed from 10 ft. to 50 ft. thick.

*Zone 2.*—Fluviatile zone with fossil wood and selenite; thickness 300—400 ft.

*Zone 3.*—Estuarine beds about 1,600 ft. in thickness, passing gradually into

*Zone 4.*—Marine beds of shale and sandstone with numerous fossil bands.

In zone 3 both marine fossils and fossil wood have been found, the fossil-bed (containing specimens of *Balanus tintinnabulum* and *Ostrea*) lying above the bed containing silicified wood. This latter bed was found in Block 46 at a horizon some 1,600 ft. below the White Sand and contained, besides fossil wood, a large species of *Ostrea* and some vertebrate remains, chiefly crocodilian.

Selenite is abundant in the zone, the thickness of which is about 1,600 ft. The zone shows pale clayey layers interstratified with somewhat current-bedded sandstones, with frequent ochre-stained bands.

Zone 4 shows well bedded sandstones and shales with numerous fossil-beds, the fauna of which has already been worked out by Noetling. The visible thickness of this zone varies, of course, with the rise and fall of the anticlinal crest, since the bottom is nowhere seen.

**Comparison of beds with those of Singu.**

The red bed and White Sand are clearly on the same horizon as those of Singu. In the Singu field perhaps the most easily recognisable fossil-bed is that of *Dendrophyllia macroriana* (*Rec. Geol. Sur. Ind.*, Vol. XXXVI, p. 147), it is about one foot in thickness, and is a reddish limestone band crowded with this coral, and containing few other species. This bed is close to the crest at Singu, and has been traced round the field by Mr. Sethu Rama Rau. It is very persistent, forming a continuous outcrop all round the crest, and lying very close to it. The same geologist has traced it in the Yenangyat field as far north as Block 15. Its depth here below the White Sand was calculated to be about 2,300 ft.

This corresponds very well with its horizon in the Singu field, but owing to the rise of the anticline, it is at a much greater distance from the crest in the Yenangyat field. The occurrence of this bed in both fields confirms the belief that the beds exposed at the crest at Yenangyat are of a lower horizon than those exposed at Moksoma Kon in the Singu area, and the fact that the former have been regarded as Yenangyaungian by Noetling, while the latter have been mapped as Promeian, shows that Dr. Noetling's division of the Pegu beds into Yenangyaungian and Promeian is perhaps of somewhat local value.

The upper beds of the Pegu series at Singu are of a shallow marine type, in contrast to the fluviatile and estuarine characters of zones 2 and 3 in the north of the Yenangyat field.

The Irrawaddy Sandstone beds of the area do not call for any special description, as they are very similar to those of other fields. It is perhaps worth noting that Mr. Sethu Rama Rau has found in Block 28 a ferruginous bed just above the Red Earth and White Sand beds, containing fossil vertebrate remains. He believes this bed to correspond to that on the east of the Pegu boundary at Singu, described by Dr. Noetling (*Pal. Ind., New Ser.*, Vol. I, pt. 3, p. 31). He observes also that the fossil wood found near this horizon is calcified, while that of the red bed below it is silicified. Calcified fossil wood has also been found in the same horizon in the Irrawaddy series near the eastern and western boundaries of the Pegu outcrop in the northern part of the field.

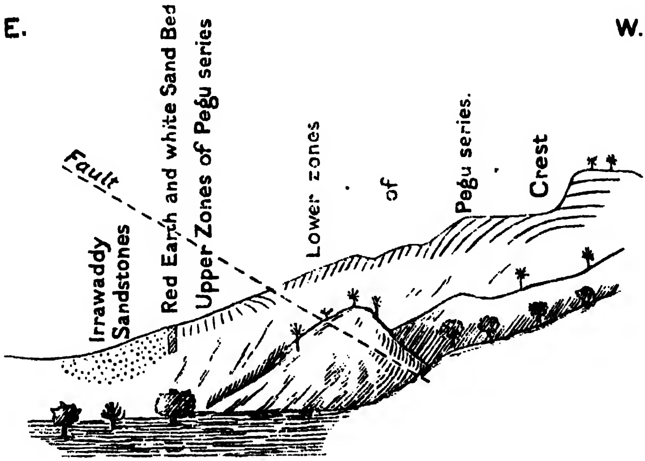
**The eastern boundary.**

Allusion has already been made to the missing Pegu beds along the eastern boundary at Yenangyat. The question has been discussed by Grimes (*op. cit.*) who decides in favour of unconformity. The unconformity is difficult to explain. The absence of the Red Earth bed, the White Sand, of zone 2, of part at least of zone 3, along the greater portion of the eastern boundary, and of the whole of zones 1, 2, and 3 at Yenangyat village, shows that this unconformity is a very considerable one, 2,500 ft. of strata being absent according to Grimes. It is surely strange that no trace of such an unconformity should be found on the western boundary, either in missing beds or in marked difference of dip: yet it is conceivably possible that this may be the case.

Another objection is that the unconformity, if unconformity it be, lies underneath the White Sand horizon in certain localities in the north of the field (where, as has already been pointed out, portions of the red bed and White Sand are found between Blocks 134 and 60, with missing beds below). At Yenangyat village, however, and from thence both southwards to the end of the Yenangyat field and to the north as far as Block 60, the White Sand itself is missing; hence the unconformity in the greater portion of the field lies above the White Sand, and below it in localities in the north. A third objection lies in the fact that the boundary beds are broken, sometimes contorted, and dip irregularly. They are a mixed accumulation of Irrawaddy rock and broken Pegu strata, filled with selenite of apparently secondary origin. Their condition strongly suggested faulting to me.

A fourth objection is that nowhere have I observed signs of erosion, such as water worn boulders, or pebble beds or other evidence suggesting unconformity along the eastern boundary. Some bed representing an old soil or beach might conceivably mark a line of great unconformity. Grimes, in discussing the question, says :—"That it is not faulted is, I think, evident from the very steep, almost vertical, dip of both series, so that if the difference in thickness of the Miocene beds were due to faulting, the throw of the fault must be very great, and so much so as to be out of the question." This objection of Grimes is certainly valid against the supposition of a down throwing fault with a steep or vertical hade, but not against a thrust-fault with a moderate or considerable hade to the west. If there be a thrust-fault here with a hade to the west we might expect to find beds bent round so as to dip west along the plane of hade. Such beds are seen in a section along the cart-road to the Burma Oil Company's bungalow on Block 134. The section is given

below. It will be seen that in this section the line of possible fault should be placed a little to the west of the Pegu boundary. Elsewhere it coincides with the boundary.




In this section the Red Earth bed, the White Sand, and some of zone 2 are exposed on the east, the dip being somewhat irregular near the fault. At the fault the beds are contorted, and there is an exposure, showing them dipping gently west. West of the fault, we find the normal easterly dip, until the crest is reached.

Strata dipping west can also be observed in Block 60, where the section is rather similar, but the fault is on the boundary.

Although the beds near the boundary dip steeply and almost vertically (except on the actual line of fault, where they can be seen occasionally to dip gently west), the beds near the anticlinal crest and east of it, dip at angles usually less than 60° to the east. There is a somewhat sharp transition from the gentle dips to the steep, which from Block 9 to Block C can be traced as a sharp fold. Sections of this fold are well exposed on the footpath to No. 7 tank, Burma Oil Company and also close to Ayadaw village. A great objection to the explanation above given is that it seems unlikely that a thrust-fault should occur in strata so little contorted or disturbed as those of Yenangyat. Local unconformity between the two series is found at Yedwet and elsewhere; and the anticlines of Yenangyaung and Yedwet were evidently formed by very gentle forces. It may, therefore, seem improbable that a

thrust-fault should occur in this area. I wish to leave the question undecided, and although it has been shown that there are some difficulties in accepting Grimes' explanation, I should wish the alternative given above to be regarded merely as a tentative suggestion, which can be decided by some future geologist better qualified than myself to deal with the subject.

**The crest.**

The relations of the surface and underground crests of this field have been discussed by Pascoe (*Rec. Geol. Sur. Ind.*, Vol. XXXIV, p. 253), and it will be sufficient to describe the direction and rise and fall of the crest in the north of the field.

From Block 134 northwards, its direction is 23° W. of N., and it is sinking rapidly, the Pegu series disappearing under Irrawaddy rocks at Thangyi Daung. The anticlinal structure is seen in Irrawaddy strata in sections on the Pauk-Pakokku road, where the crest crosses near the 27th milestone. Southwards from Block 134 to Block 50, the direction is 20° W. of N. In the Ye-ga block (Block 48) immediately south of Block 50 the crest suddenly changes its direction to S.—N., and in consequence of this the strata near the crest on the western side have become squeezed up, the dips near the crest being much steeper than those taken from strata 1,000 ft. west of it. This change in strike is indicated in Pl. 29.

In Block 123, the crest is rising to the south at a slope of less than 2° according to observations taken with prismatic compass and Abney level. It continues to rise as least as far south as Block 67. Grimes speaks of a crest-maximum in this block, on the Sabe-Ledaing cart-road. I have found no evidence to corroborate this. The Pegu outcrop gradually increases in width to the south. The dips taken in the blocks south of 67 did not suggest that the anticline was sinking southwards. It would however be necessary, I think, to decide this point by mapping recognisable beds by means of large-scale maps, and the largest scale available being on a scale of 1 inch = 1 mile, I was unable to decide the question.

**Prospects of oil.**

The country to the north of Block 134 may be condemned, since the crest sinks too rapidly. From Block 123 southwards the country seems worth testing; the blocks will probably increase in richness to the south at least as far as Block 67, owing to the rise of the anticline.

# ON SOME IRON ORES OF CHANDA, CENTRAL PROVINCES.

BY P. N. DATTA, B.SC., *Assistant Superintendent, Geological Survey of India.*

IN the north-eastern quarter of the district of Chanda, Central Provinces, surveyed during the season 1907-08, iron-ores were found in three localities, *viz.*, (1) Lohara, (2) Asola, and (3) Dewalgaon.

(1) Lohara (20° 24′, 79° 46′ 30″).—The Lohara ore (specimen K. 254) was reported on by the late Mr. Hughes of this Department as long ago as 1873. He refers to it as a compact crystalline hæmatite or specular iron ore with some magnetic oxide. Although he describes the iron-mass at Lohara as striking, forming a "hill fully ⅜th of a mile in length, 200 yards in breadth and 100 to 120 feet in height," he was not able at the time to follow the lode southwards, though he thought that the length of the lode might exceed several miles.[1] The ground was further explored during the last season with the following result:—The lode as mentioned by Mr. Hughes forms a hill. The northern extremity of this hill, where the ore is first found well exposed on coming from the northern direction, lies about ½ mile south of the little hamlet of Lohara, the strike of the hill—which is also that of the lode—being in a north-east by east to south-west by west direction. The hill as one follows it south-westwards loses in height until at about 1½ miles south-west of Lohara it becomes quite low, being thenceforward further traceable only as a very low ridge. Southwards it passes through Aliwahi (20° 22′ 30″, 79° 45′) and, gaining somewhat in height ½ mile further south, finally disappears about a mile south of the village. The iron-bearing rock band either dies out here or is concealed by alluvium; the former contingency is the more probable one, for close to

[1] *Rec. G. S. I.*, VI, p. 77.

its southern visible extremity a granitoid gneiss is seen to crop out.

The rock of the band, as seen at this southern extremity, or by the village of Aliwahi, or about a mile east by north of it, is a hæmatite-quartz-rock, somewhat laminated or foliated—the quartz and hæmatite making up the rock—; but the proportion of silica is so large in these localities as to render it valueless as an ore. So although the actual length of the lode may be slightly greater than is indicated in the estimate furnished by Mr. Hughes in his report, his expectation that it might prove several miles long has unfortunately not been fulfilled, though, as it is, the quantity of ore available must be very large. According to an analysis published in the *Colliery Guardian*, the chemical composition of the ore is as follows:—

| | |
|---|---|
| Iron, metallic | 69·208 |
| Oxygen, in combination | 29·376 |
| Manganese sesquioxide | ·090 |
| Silica | ·823 |
| Alumina | ·432 |
| Lime | ·054 |
| Magnesia | trace. |
| Sulphur | ·012 |
| Phosphorus | ·005 |
| | 100·000 [1] |

(2) Asola (20° 13′ 30″, 79° 52′).[2]—Asola is a little hamlet 2 miles south-east of Gunjewai. The ore, consisting of hæmatite, occurs on the northern edge of a low hill striking north-west—south-east,

[1] *Colliery Guardian*, September 13, 1873.

[2] Samples from this and the succeeding locality (Dewalgaon) consisted of chips, which were broken off from the parent-mass, at intervals, all along the length of the exposures. All the fragments of the ore thus collected were handed over to the Curator of the Geological Laboratory for assay; for the samples collected were not large (it was difficult in places to break off more than a chip or so, with the ordinary hammer, owing to the hardness of the rock), and no coning and quartering had been attempted in the field. The average weight of the samples was probably about 30 lbs. from each locality. From each of the fragments of rock one or two pieces (according as the specimen was small or large) were chipped off; these chips were then coned and quartered, and the portion for analysis thus selected.

which is also the strike of the lode, its dip being 35° to 40° to the north-east. The lode lies about 1 mile north-west of Asola and 1½ miles south by east of Gunjewai. Mr. Hughes in his report on the Wardha Valley Coalfield simply refers to it as the Gunjewai lode, giving however no details.[1] As Gunjewai, though hitherto a large village, is now doomed to insignificance or disappearance on account of the great irrigation tank at present in execution at Asola which will thus become henceforth well known, I have indicated the lode as the Asola lode.

The lode is traceable on the surface for about 400 yards, with an average thickness of 30 to 40 feet.

Analysed at the Geological Survey Laboratory (Specimen K. 253) the percentage of metallic iron was found to be 65·99 and of silica 3·89. A complete analysis not having been made, it is not known what minor constituents might be present in the ore.

(3) Dewalgaon (20° 24′, 80° 1′ 30″).—Half a mile south by east of Dewalgaon is a bare bluish-black crag, formed of quartz with hæmatite. The proportion of iron in the rock as broken off from this crag is so small that it cannot be regarded as an ore.

This proportion, however, evidently varies, and this variation must be fairly rapid in places; for pieces of what is a valuable iron ore, found buried beneath the soil, the result no doubt of weathering, are now dug out (and have been so for many years now, so far as I could gather) by men and women, from the southern foot of the crag, to be smelted.

About the village of Dewalgaon itself, two lodes of hæmatite were discovered, one being about 100 yards north-west and the other about 400 yards south by east of the village. These may be conveniently referred to as the (*i*) North-western, and (*ii*) Southern lodes.

(*i*) North-western lode.—The ore is a hæmatite and so far as it is exposed, the lode is 255 feet long, with a thickness of 4′ 6″. But, for a length of 30 feet (out of the 255 feet), the thickness increases to 9′ 6″. Owing however to alluvium and soil of cultivation it is impossible, without actual excavation, to say whether the lode extends further in length and breadth. The dip is west by south at 50°.

[1] *Mem. G. S. I.*, XIII, pt. 1, p. 110.

Partial analysis in the Geological Survey Laboratory gave 61·2 and 11·04 as the percentages of metallic iron and silica respectively.

(*ii*) Southern lode.—The visible northern extremity of the lode, also a hæmatite (K. 256), is about 400 yards south by west of the village and is traceable south-eastwards for about 300 yards, with an average width of 20 feet. Beyond this point, *i.e.*, towards the south, the rock becomes less ferriferous, as seen on the crag already alluded to. The variation in the percentage of iron in the rock must be somewhat capricious, for at the southern foot of the crag an ore of a fairly good quality has been and is at the present day dug out from underneath the soil, indicating that the outcrop, though it may be unpromising at one spot, may yet yield a fair ore, even in its immediate neighbourhood. A little further south-east from the foot of the crag, the rock becomes a pure quartz, free from association with iron.

Chemical analysis in the Geological Survey Laboratory gave 67·76 per cent. of metallic iron and 1·50 per cent. of silica.

Whether the north-west lode is continuous with the southern one, it is not possible to be perfectly certain, without actual excavation. The village itself shows nothing but laterite; but as this laterite is very like that into which a portion of the north-west lode was clearly found to have been converted, it is very probable that the village stands on a lode, being the connecting middle portion between the north-west and south lodes.

The following statement as to the deposits of iron ore of Bissí, Pipalgaon and Ratnapur as given by Mr. Hughes in his paper on the Iron Deposits of Chanda may be added here, as this will make a fairly complete statement as to the occurrences of iron ores in the district, so far as yet known:—

"BISSÍ.—Long. 79° 28′ East, and Lat. 20° 39′ North.—The ore occurs in a lode about a mile directly east of the village and contains hæmatite and magnetic oxide of iron."

"PIPALGAON.—Long. 79° 34′ East, Lat. 20° 32′ North.—An excessively fine mass of red hæmatite, resembling that which occurs at Loháñá, and having probably the same composition, is to be seen about three-quarters of a mile east of Pipalgaon. The strike of the lode is west-north-west, east-south-east."

"RATNÁPÚR.—Long. 79° 37′ East, and Lat. 20° 23′ North.—A very rich lode of brown iron ore, forms a terrace on the north side of the small range of hills facing Alísúr. The width of the lode in places is 40 and 50 feet."[1]

*Pipalgaon ore*, as analysed by Mr. Ness[2]:—

| | | |
|---|---|---|
| Protoxide of iron | 63·0 | |
| Peroxide of iron | 31·5 | |
| Lime | ·5 | |
| Magnesia | trace. | not estimated. |
| Phosphorus | do, | not estimated. |
| Sulphur | do. | not estimated. |
| Silica | 4·5 | |
| Water traces and loss | ·5 | |
| | 100·0 | |
| | metallic iron 71·05. | |

*Ratnapur ore*:—

(1) Analysis by Mr. Ness—

| | |
|---|---|
| Metallic iron | 49·7 |
| Insoluble | 26·0 |

(2) Analysis by Mr. Tween—

| | |
|---|---|
| (*a*) Metallic iron | 50·5 |
| Insoluble | 22·8 |
| (*b*) Metallic iron | 52·0 |

(3) Analysis of laterite near Ratnapur—

| | |
|---|---|
| Metallic iron | 25·7 |

*Yenak Hill.*—Conglomeratic bands in this hill contain pebbles of hæmatite, with 56·3 to 68·5 per cent. of metallic iron, and with mere traces of phosphorus and no manganese.[3]

[1] *Rec. G. S. I.*, VI, p. 78.
[2] *Mem. G. S. I.*, XIII, pt. 1, p. 111.
[3] *Mem. G. S. I.*, XIII, pt. 1, p. 111.

# THE GEOLOGY OF THE ADEN HINTERLAND. BY CAPTAIN R. E. LLOYD, M.B., D.SC., I.M.S., *late Surgeon-Naturalist, Marine Survey of India.* (With Plates 30 to 33.)

THESE notes were made after a three weeks' tour in the Aden Hinterland, which was taken at the instigation of the Political Resident of Aden, Major-General H. M. Mason, during the early part of 1906. The opportunity for making this tour arose unexpectedly, so that I was unacquainted at the time with the previous work on the geology of the Aden district. My attention has since been drawn to two papers on the geology of Aden and the neighbourhood. Mallet[1] examined the crater of Aden, and the desert country to the north as far as the foot-hills, with reference to the advisability of sinking artesian wells in the district. He writes: "from Majhafa, I marched nearly due north to the foot of the hills, but on account of the disturbed state of the country I was unable to enter them." He was, however, able to examine the outlying hills and described in them a thick sedimentary series of limestone and superimposed sandstone. The limestone contained fossils, which were referred to by Dr. Stoliczka, in the following words: "The few fossils appear to resemble most upper jurassic forms, though the same genera also occur in lower cretaceous beds."

McMahon[2] has described the petrological characters of lavas taken from the Aden crater, about which nothing is here recorded.

The line of country examined by the present writer extends due north, from Aden on the coast to the town of Dala, ninety miles inland. The southern half of this is a flat desert devoid of outcropping rocks; it was described by Mallet.

At the time of my visit it was possible to travel forty miles through the hills to Dala: although to wander from the road to any extent was still considered unadvisable. The road enters the foot-hills at the village of Nobat Dakim and gradually ascends to Dala, which lies among hills six or seven thousand feet in altitude.

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[1] *Mem., Geol. Surv. India,* VII, p. 257, (1871).
[2] *Rec., Geol. Surv. India.* XVI, p. 145, (1883).

A short description of the geology of the hills seen on the road, with a somewhat fuller description of the rocks immediately round Dala, form the subject of these notes. The rocks may be divided at once into two divisions, a sedimentary series of limestones and sandstone (previously described by Mallet), and a more recent igneous series, which, in this part of the country, is represented in a much wider area than the sedimentary rocks. The igneous rocks, comprising more than nine-tenths of the area examined, will be described first.

For descriptive purposes they may be separated into three divisions:—

(1) The horizontally bedded lavas.
(2) The beds of volcanic ashes.
(3) The massive lava.

## 1.—The Bedded Lavas.

Rocks of the first division are best seen in the immediate neighbourhood of Dala. The town of Dala is situated at the southern end of an extensive plain, which is about 10 miles in length from north to south, and 3 or 4 miles in breadth at its southern end, but which widens out considerably towards the north. This plain slopes gently to the north and is surrounded, except at the north-west corner, by a rampart of hills, rising two or three thousand feet above it. On the west the plain is bounded by a group of hills known as Jabal Jihaf. This range does not join the northern boundary of the plain, being separated therefrom by a wide gap, through which the drainage of the whole area leaves by the Kataba stream to join the Wadi Tiban (see map and Plate 31). The northern boundary is a long escarpment which marks the southern limit of the Mares and Shaibi districts. The eastern end of this escarpment curves in a southerly direction to join a range called Jabal Harir, which forms the eastern boundary of the plain. The Dala hills, on which the town itself is situated, mark the southern limit of the plain. These hills are very uniform in structure, consisting of layers of compact black lava, alternating with layers of amygdaloidal lava.

The latter is usually in a soft crumbly condition and weathers away readily, leaving the layers of compact lava standing out in relief.

From the alternation of these layers a very distinct appearance of stratification results, which is best seen on the northern aspect of the hills, where they face the plain (Plate 30).

Immediately around Dala these lava flows dip towards the south at angles of 20° to 30°. To the west, where the Dala hills are continuous with the Jabal Jihaf range, the layers dip to the south-south-west and south-west at similar angles. Further to the north in the direction of Sana and beneath the northern end of the Jabal Jihaf are low hills of a similar structure, the component layers of which, although somewhat irregular as regards plane of bedding, show a general tendency to dip to the west. In considering these rocks as a whole as regards direction of dip, it will be noticed that this is along lines arranged radially away from an imaginary point situated near the middle of Dala plain.

Regarding the direction of dip in the escarpments of the Mares, Shaibi and Harir districts, nothing can be said from personal observation, as it was impossible to visit them: but to an observer standing in the middle of Dala plain, the appearance of these escarpments is that of a series of horizontally disposed strata (Plate 31). A similar horizontal appearance is offered by the Dala hills from the same point of view. These latter hills, as above mentioned, dip to the south and south-west away from the centre of the plain, and it is probable that the strata composing the escarpments of Mares, Shaibi and Harir also dip away from the centre of the plain in a north and north-easterly direction as they would if deposited from a centre of volcanic activity situated near the middle of Dala plain.

As previously mentioned, the stratified appearance of all these rocks is due to the alternation of compact lava with soft amygdaloidal rock. The compact lava, which is the predominant rock of the neighbourhood, is tough and black, with porphyritic crystals of a translucent green mineral. Mr. H. Walker of the Geological Survey of India has kindly given me the following description of it. "A porphyritic dolerite of medium grain. Olivine occurs in large idiomorphic crystals, and augite occurs in two generations; the older as a large porphyritic one and the younger as a fine granular generation. The rock is fresh." The layers of the rock vary in thickness from one to twenty feet. These layers or sheets of lava extend laterally over a considerable distance, as much as half a mile or more in some cases, though many are of less extent.

They terminate laterally by thinning down and passing into the rotten amygdaloidal rock. This latter appears to be of similar composition to the compact lava, but contains innumerable globules of a white calcareous mineral, which are assumed to be steam vesicles filled by infiltration.

Besides the bedded lava there occurs a compact fine-grained trap devoid of porphyritic crystals; this is disposed in vertical dykes intrusive into the other rocks. These dykes are often about 3 or 4 feet in thickness and in the neighbourhood of Dala lie approximately east and west.

Bedded lava with intrusive dykes is the prevailing rock in the immediate neighbourhood of Dala. The several isolated hills on the Dala plain such as Jabal Shahad, Jabal Asoda are of this composition; and judging from the appearance they present in the distance, the escarpments of Mares, Shaibi and Harir are of a similar nature. In regard to their origin there seems little doubt that they were formed sub-aerially by successive lava flows, the central part in the thickness of each flow forming the compact layer, above and below which the lava is amygdaloidal. The regularity with which these layers dip away from a point about the middle of Dala plain, suggests the view that the successive lava flows issued from a crater whose axis occupied this position. And further it seems that except for extensive erosion and slight mineral changes, the rocks have not been much altered since the date of their deposition.

## 2.—The Beds of Volcanic Ashes.

These occur locally to the south and west of Dala; they are to be found on the road from Dala to Dabiyat about four miles from the latter place, also on Jabal Jihaf, both close to the Dala plain and in the neighbourhood of Karna, where the newly made Al Hakl road has been cut through them. These rocks catch the eye at once, owing to the brightness and variety of their colours: light green, pink, red, yellow, buff, chalk white and other tints. Although differing greatly in colour, these various rocks resemble one another in being finely stratified. Their smallest particles usually show a horizontal arrangement. These beds are never disposed horizontally, but dip at pronounced angles, usually less than 30°.

In Jabal Jihaf they dip to the south-west, but towards Dabiyat they can be seen dipping towards any point of the compass, and occasionally beds of one colour lie unconformably over beds of another colour. The ash beds of Jabal Jihaf show an interesting feature in the form of narrow layers of light brown siliceous rock. These layers are about 6 inches in thickness and lie a few feet apart. They show well marked foliation, and conform in position to the beds of ashes among which they lie.

These brightly coloured rocks were probably formed from volcanic ashes, in part air borne perhaps, but chiefly mixed with water in the form of volcanic alluvium or aqueous lava, the siliceous bands being deposited in the form of siliceous sinter from hot springs, during the formation of the ash beds. They seem to have been little disturbed since the time of their deposition.

## 3.—The Massive Lava.

These rocks being situated above the others have an important influence on the appearance of the country. They form plateaux and pinnacle-rocks which give a characteristic appearance to the landscape.

Good examples of plateaux are seen in Dabiyat and Mafari; these are flat-topped hills of considerable area situated to the south of Dala. That of Dabiyat is about $1\frac{1}{2}$ square miles in area. They are bounded on all sides by perpendicular cliffs about 200 feet in height, composed of compact grey dolerite, which thus forms a flat cap to the hill, resisting erosion and giving to the hill its characteristic shape. Both plateaux are about 6,000 feet above sea level. They are only six miles apart and must have resulted from one great sheet of lava of many miles extent.

Many of the pointed hills in the Jabal Jihaf group are also capped with 100 feet or more of this same lava.

Besides occurring in the form of plateaux and points capping the summits of the higher hills, the massive lava occurs not uncommonly in the form of pinnacles which appear to be eroded necks of lava occupying the lesser volcanic vents. A good example of such a pinnacle rock is seen about a quarter of a mile to the north of the Dabiyat plateau (Plate 32). Here the coloured ash-beds are to be seen sloping away from the central column of lava.

The elevated position of these plateaux and pinnacles show that the massive lava is of a later date than the rest of the volcanic series. Probably at this later date a great outflow of lava occurred, filling up the numerous smaller vents and forming an extensive sheet over the whole district. This probably brought the active volcanic period to a close and there has been little change since, except for the extensive erosion required to bring the hills to their present shape.

Before concluding the description of the igneous series the commoner infiltrating minerals, present in these rocks, must be mentioned. Calcite in various forms is the most common. Nests of pure calcite crystals are frequently met with. The white mineral which occurs throughout the amygdaloidal lava has a calcareous basis, though it is not entirely soluble in strong acid. Quartz, both in crystalline and milky chalcedonic form, occurs more rarely. Hæmatite is very commonly diffused through the rocks, but is rarely met with in any quantities in a pure form.

## The Sedimentary Rocks.

Sedimentary rocks were met with at two places: in the valley of the Bilih between Nobat Dakim and Almilah and to the east of Sulaik in the valley of a stream which flows down from the village of Masra. At both places the rocks are of the same nature, consisting of a fossiliferous limestone with a superimposed sandstone of considerable thickness, both altered by contact with the later igneous series. The sedimentary rocks are best displayed on the south side of the Masra valley, two miles from Sulaik Fort. Here the limestone is highly fossiliferous and the sandstone is seen resting upon it.

The limestone is composed of compact layers of stone which vary in thickness from 2 or 3 inches to as many feet. These layers alternate with softer shaley bands which weather away, leaving the harder rock in relief. The surface colour of the rock is light grey. In outward appearance it presents, as a whole, a close resemblance to the lower Lias as seen in the sea cliffs of Dorsetshire. The resemblance does not extend to the internal structure, however. This rock is very tough and breaks often with a semi-conchoidal fracture. A fresh fracture shows a dark, almost black, surface, with some crystalline sparkle. At the place where it was examined the

limestone dips to the west at an angle of 25°, forming part of an open anticline, which, owing to restrictions, was not fully explored. Not more than 300 feet of the limestone was seen, for its lowest part was lost beneath the river bed. The change from the limestone to the sandstone is rather sudden. Towards the upper part of the limestone the shaley beds predominate, but layers of compact limestone occur only 15 feet below the typical sandstone.

Fossils abound in this limestone. Good specimens however are difficult to obtain, for on breaking the rock the fractures usually pass through the fossils. From the weathered surface several fossils were obtained; they include three species of ammonites, belemnites of more than one species, the joints of *Pentacrinus*, and molluscs of the genera *Trigonia*, *Pinna*, *Pecten*, and a gasteropod.

The *Trigonia* closely resembles *T. costata*. These fossils are of Upper Jurassic age and are described by Mr. G. H. Tipper on pages 336—340.

The thickness of the sandstone in the Masra valley must be at least 2,000 feet. It shows a well marked plane of bedding which, like the limestone, dips to the west at an angle of about 25°. The colour of the fresh surface is generally a light buff, in places it is almost white with a pinkish tinge, in other places it shows red mottling from iron. The individual sand grains are rather coarse and in many places the rock could be described as a coarse grit. Throughout, the sandstone is very compact in structure, the individual grains cohering very firmly, and locally this peculiarity is so marked that the rock becomes a quartzite. The structure known as "false bedding," characteristic of shallow water deposition, is frequently seen. Towards the upper part of the sandstone, beds of small pebbles occur; these are generally of pink or white semi-translucent quartz and are obviously water-worn. No signs of organic remains were met with in this sandstone.

The highest part of the formation is seen at the western end of the valley, about half a mile from Sulaik Fort. Here some interesting features appear. Interstratified with the normal sandstone are beds composed largely of volcanic fragments, pebbles of lava, and coarse ash, intermingled with quartz grains; all clearly of aqueous deposition. Examination of this part of the series leads to the assumption that the volcanic period gradually succeeded the deposition of the sandstone without the intervention of any great space of time.

The sedimentaries in the valley of the Bilih are of the same type as those of Masra, but it happened that they were less accessible for examination. The limestone of the Bilih is more massive and less shaly than the other, the fossils in it are fewer, while trap dykes abound. It is tough, black and crystalline. The sedimentaries are widely represented to the east and west of the line of country examined.

# PETROLOGICAL NOTES ON THE ROCKS COLLECTED BY CAPTAIN R. E. LLOYD, NEAR ADEN. BY E. W. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 34.)

## Contents.

## Introduction.

From the interesting notes supplied by Captain Lloyd on the subject of the geology of the neighbourhood of Aden, it appears evident that, apart from the products of quaternary eruptions constituting the Aden volcano, the rocks examined belong at least to two geological periods. There is an older series of sedimentary rocks shown by their fossil contents to be of Jurassic age, and a newer series of volcanic rocks associated with aqueous sediments. The exact manner in which this association occurs is not quite clear from the descriptions available, but it is probable that, at least in some cases, the volcanic rocks represent true contemporaneous intercalations, probably of the same age as the interbedded sedimentary and volcanic rocks of Upper Cretaceous age which occupy such large areas in Balúchistán and Persia, where they constitute the local representatives of the Deccan trap of the Indian Peninsula.

Two points remain slightly obscure from the available descriptions; these are the mutual relations of the bulk of the volcanic rocks to the overlying formation described as "the massive lava," and also the exact age of the intrusive dykes that traverse the bulk of the volcanic formation but are not mentioned in connection with the "massive lava."

It seems, from the published description, that the "massive lava" is almost horizontally bedded, very much after the manner of the Deccan trap in the plateau-forming accumulations of the Deccan and Malwa in the Indian Peninsula. The quaquaversal dip of the volcanic beds away from the Dala plain is regarded as an original feature, indicating the position of a former centre of volcanic activity from which all the beds sloped away in radial direction. If this be really the case, the unconformity of the "massive lava" need not imply any great difference in age. It is very doubtful, however, whether this interpretation be correct, for, so far as can be gathered from the descriptions, the sedimentary intercalations at Saleik share the dip of the volcanic rocks; and this would suffice to show that the inclination of the beds cannot be an original feature, and that the structure of the Dala plain and its surrounding scarped rim is that of a dome-shaped anticline of tectonic origin, whose structure has been acquired long after the accumulation of the volcanic series, and which is analogous in disposition and origin to similar features observed in certain parts of

Western Sind and of Kachh. That being so, the undisturbed "massive lava" might be of much later date, and might be contemporaneous with the volcanic system of quaternary age to which belong the Aden volcano and other volcanoes of the south coast of Arabia. Nevertheless, the enormous amount of denudation which it has undergone rather favours the idea that it is a true member of the older volcanic formation, the appearances of unconformity and horizontality being perhaps deceptive.

As regards the intrusive dykes mentioned by Captain Lloyd, it is not possible, from the data available, to make certain whether they belong to the period of activity of the older, probably Upper Cretaceous volcanic rocks, or to a later period, though the descriptions rather suggest a connection with the "massive lava."

The numerous specimens are mostly unaccompanied by stratigraphical indications and do not help therefore to elucidate these uncertain points.

## Jurassic Rocks.

The Jurassic rocks represented in the collection are chiefly compact limestones whose colour on the fresh fracture varies from grey to nearly black, and whose exposed surface weathers with a thin somewhat buff-coloured crust, the tint becoming often distinctly ferruginous where certain fossils have weathered in relief. These fossils constitute the chief interest of the specimens, and have been described by Mr. Tipper.

## Probable Representatives of the Deccan Trap.

There is a large collection of specimens from the older volcanic series, and although there is a slight uncertainty as to whether some of them may have been obtained from the intrusive dykes or "massive lava" of uncertain age, the bulk of the collection recalls so completely the assemblage of rocks which it is customary to meet with in the Upper Cretaceous volcanic formation of Balúchistán and Persia, that their petrographical facies taken in connection with their evident superposition upon the Jurassic rocks leaves little doubt as to their belonging to the same formation. Rocks of this age are largely represented in the Indian Peninsula by the vast accumulation known as the Deccan trap, a basaltic formation whose chief petrological peculiarity is the scarcity or absence of the mineral olivine.

The bulk of the Upper Cretaceous volcanics outside the Indian Peninsula consists of andesites, though one frequently observes intercalations of basalts quite as basic as those of the Indian Peninsula, and occasionally rhyolites. The extra-peninsular basalts of this period generally contain olivine, and differ thereby from the basalts of the peninsular Deccan trap.

## THE DALA COLLECTION.

Most of Captain Lloyd's specimens have been collected near Dala, and they include a very complete assemblage of rocks such as usually characterise the extra-peninsular facies of the Deccan trap.

The Dala collection includes the following types of rocks (the numbers being those under which the specimens are registered in the Geological Museum at Calcutta):—

Rhyolite or devitrified obsidian, 21-153.
Rhyolites, 21-112, 137, 138.
Rhyolitic ash-beds, non-calcareous, 21-110, 111, 113, 114, 115, 116, 134, 135, 142, 143, 144, 145, 146(*a*), 147.
Rhyolite-breccias, 21-126, 127, 128, 132, 133.
? Altered andesites, 21-120, 121, 129.
Fine-grained dolerites, 21-131, 139.
Ordinary basalt, 21-118.
Augite-basalt, 21-140.
Scoriaceous amygdaloidal basalts, 21-119, 125.
Basalt weathering spheroidally, 21-152.
Olivine-basalt, 21-130.
Basalt, exceptional type with epidote, 21-141.
Olivine-porphyry basalts, 21-123, 124.
Substances of the same type as usually occur in the large geodes of the Deccan trap; including agate and quartz, 21-109, 148, 149, 150; chalcedony, 21-151; green jasper, 21-117; red ferruginous jasper, 21-174; red jasper interbanded with chalcedony, 21-136; chert and opal, 21-159-163; calcite, 21-122; calcite stained black with manganese oxide, 21-162.
Sandstones, 21-154-158.

### *Acid Rocks.*

The above list shows that the prevailing types of rock in the Dala collection are either distinctly acid or distinctly basic, the intermediate andesites being doubtfully represented by a small number of rather obscure specimens.

The acid rocks are represented by rhyolitic lavas, rhyolite breccias and ash-beds.

It should be noticed that these rocks never contain any plagioclase felspar, except among foreign fragments in some of the ash-beds. They are therefore true rhyolites, and not pseudo-rhyolites approaching dacites like certain lavas of Gujrat (Pawagarh Hill) and Kathiawar in the Deccan trap outcrop of India.

The proportion of silica in one of these rocks (21-112) determined by Mahadeo Ram, Laboratory Assistant, is 73·54 per cent., which indicates a typical rhyolite, whilst in the pseudo-rhyolites of Pawagarh hill the proportion never reaches 70 per cent. (*Rec. Geol. Surv. Ind.*, Vol. XXXIV, p. 158). Some of the features exhibited by these rocks are sufficiently interesting to deserve special notice.

**Rhyolitic lavas.** The specimen numbered 21-112 is a good example of the normal rhyolites. Its specific gravity is 2·47.

The rock, in its unaltered portion, consists of a pale greenish-grey groundmass through which are scattered numerous porphyritic crystals of orthoclase felspar from 1 to 4 mm. in diameter and a few crystals of quartz of about 1 mm. The felspar crystals are opaque-white, the quartz crystals transparent. The rock is altered in places where it is stained red, the colour spreading over the felspar crystals and recalling the appearance of "rosso antico". The proportion of the felspar phenocrysts is almost one-half of the bulk of the rock.

Under the microscope, the base is obscurely cryptocrystalline, profusely strewn with dust-like opaque particles not more than 0·005 mm. in size and with fairly numerous minute crystals of quartz or felspar of about 0·05 to 0·1 mm. in dimension.

The felspar phenocrysts show crystal outline, cleavage cracks, but no twinning. They are occasionally aggregated in glomero-porphyritic groups. The quartz crystals exhibit the corroded outline characteristic of rhyolites. There is sometimes a shallow fringe of secondary growth round the felspars.

The rock numbered 21·138 (Plate 34, fig. 1) is a very fresh-looking, lilac-coloured rhyolite, rather cavernous. It contains porphyritic felspars of about the same size as in the previously described rock, their proportion as compared to the base being somewhat less. Quartz phenocrysts are somewhat more abundant. Flow-structure is conspicuous both in the hand specimen and microscope slide. The microscopic structure generally closely resembles that of the rock previously described. The felspars are all orthoclastic, quite fresh, and occasionally twinned. The base is finely crystalline, this being partly the result of secondary devitrification. The outward appearance of the rock differs from that of the previously described rhyolite, the porphyritic aspect being far less evident in consequence of the freshness of the sanidine-felspars, which have remained transparent instead of showing as opaque white patches.

**Rhyolitic ash-beds.**

The rhyolitic ash-beds, which form such a large proportion of the collection from Dala, are fine-grained, often sharply-bedded, rough-fractured to porcellanoid rocks, usually of a fresh bright-green colour. The typical members of this group of rocks are non-calcareous. Owing to their fine texture, the nature of the component grains cannot be clearly made out by means of an ordinary lens. Under the microscope one distinguishes fragments of volcanic quartz, volcanic felspar, glass and pumice. The rock is non-calcareous. The ash-beds of Pawagarh Hill in the Indian province of Gujrat are very similar, but of a much less vivid colour.

Most of these ash-beds are of a vivid light-green colour (21-110, 114, 115, 116, 146, 147); occasionally they exhibit various tints of red, buff, grey, lilac, or white. The colouring is either uniform or disposed along bands parallel with the stratification. Several specimens are green with red spots, and, in one instance (21-134), it is to be noticed that every one of the green patches represents a fragment of pumice.

**Rhyolite breccias.**

The rhyolite breccias include grey and purplish red rocks whose fragmentary nature is evident in the hand-specimens. When examined under the microscope they are found to consist of fragments of rocks similar to those just described, together with fragments of volcanic glass, pumice, and obsidian.

The specific gravity of these breccias varies from 2·47 (specimen 21-132) to 2·49 (specimen 21-127).

The rhyolitic ash-beds from Dala are not calcareous, but the breccias are often distinctly so (particularly the specimens 21-126, 127, 133), calcite impregnating the fine-grained dust between the larger fragments.

## *Doubtful Andesites.*

Captain Lloyd's collection does not contain any typical andesites, though there are a few specimens that may perhaps be related to this group of rocks. One of the characteristics of the rhyolitic rocks above described is the absence of calcite amongst the decomposition products, except in the case of the breccias, where the calcareous matter may be of foreign origin. There are, however, a few highly felspathic rocks, of low specific gravity in which the abundance of secondary calcite suggests the original presence of a certain proportion of plagioclase felspar, while there is, at the same time, a complete absence of porphyritic quartz crystals amongst these particular rocks. They are grey to lilac-grey, trachytic-looking, fine-grained rocks, the fracture of which exhibits a peculiar sheen, owing to secondary calcite having crystallised in crystallographic continuity over large areas. Occasionally they are superficially stained red, like some of the rhyolites. When examined under the microscope, they are found to have a minutely crystalline felspathic base, resembling that of some of the felso-rhyolites already described, while the porphyritic crystals are, in one case (21-120), phenocrysts or glomero-porphyritic aggregates of felspar entirely replaced by calcite, in another case (21-129) dark opaque patches with a crystalline outline recalling that of hornblende. The rock with the altered felspar phenocrysts has a specific gravity of 2·62, that with the dark pseudomorphs, of 2·44.

Another rock of the same category is that numbered 21-121, which shows a very distinct banded structure. The specimen consists of two portions representing two successive bands: a compact grey-lilac portion, with minute white patches arranged in parallel streaks, and a finely porous portion of brick-red colour. The porous crust must represent the marginal portion of a lava flow. Under the microscope the compact portion shows an imperfectly polarising groundmass with conspicuous flow-structure, rendered semi-opaque by a suffusion of extremely fine iron-ore dust, through which are scattered numerous minute laths of plagioclase, with their longer axis parallel to the direction of flow, and which,

from their small extinction angles, appear to be oligoclase. Their average length is 0·15 to 0·2 mm. There are also some elongated masses of calcite of about 1 mm. in length disposed in linear series along the same direction, probably representing a secondary infilling of elongated cavities. It is these that give a streaky appearance to the hand specimen. The outer finely vesicular portion of the lava has its base rendered almost opaque by the decomposition products to which it owes its red colour. The felspar laths are the same as in the compact portion, but scattered irregularly at all angles, instead of being disposed in parallel manner.

### *Basic Rocks.*

Whilst the group of the andesites is only doubtfully and uncharacteristically represented, that of the basic rocks is richly developed, and includes numerous rocks identical with those of the Deccan trap of the Indian peninsula, together with others of less familiar appearance.

The basic rocks from the Dala region include both fine-grained dolerites and true basalts.

**Dolerites.**

One of the dolerites, that numbered 21-131, is remarkable for its beautiful pleochroic augites of purple colour by transmitted light, the crystals of which are distributed in porphyritic fashion amongst the labradorites, although ophitically intergrown with them. There are also grains of iron ore. The augite grains when in the shape of short prisms average 1 mm. in width, but sometimes they assume elongated shapes when the length frequently reaches 2 or 3 mm. The labradorite prisms often reach a length of 0·7 mm., these larger crystals being accompanied by many others of smaller dimensions. The rock contains cavities sometimes over 5 mm. in diameter, lined with a devitrified glass which is yellowish green by transmitted light, the remainder of the cavity being filled with zeolites and opal and occasionally with quartz.

Another basic rock which, although fine-grained, has elements sufficiently large to be recognised without the aid of a microscope, and which is therefore entitled to rank as a dolerite, is the rock numbered 21-139. It has a "pepper and salt" appearance due to the association of opaque white felspars (labradorite) and black augites. The average length of the felspar and augite prisms is

from 0·5 to 0·8 mm. There are no porphyritic crystals. Both the labradorite and augite are colourless in thin section. Ophitic intergrowth of the augite occurs only locally. The augite is fresh, the labradorite altered. Thin sections also reveal the presence of a fair proportion of altered iron ore, and of secondary serpentine, and also some secondary calcite. This dolerite closely resembles many of the dyke-rocks of Deccan trap age that one observes in Balúchistán. Its specific gravity is 2·84.

***Ordinary Basalts.***—The basalts which seem to constitute a considerable proportion of the scarps surrounding the Dala plain are to a large extent normal representatives of this class of rocks. The specimen numbered 21-119 particularly recalls certain varieties of the Deccan trap of the Indian Peninsula. It is a vesicular purplish black rock with large glomero-porphyritic aggregates, of about 5 mm. in diameter, of unaltered labradorite and geodes of about the same size filled with calcite, zeolite, or "green earth." Under the microscope the base shows numerous lath-shaped labradorites 0·1 to 0·4 millimetres in length, scattered through an almost opaque matrix. There is no undecomposed augite.

**Basalts without olivine resembling the Deccan trap.**

Another rock not unlike some varieties of the Deccan trap is the one numbered 21-140. It is a grey compact rock with stony fracture, of even grain and without conspicuous phenocrysts. Under the microscope it appears to consist principally of augite and labradorite in approximately equal proportions, both occurring in the shape of prisms with an average length of 0·3 to 0·4mm. There is a fairly large amount of iron ore, and the section appears much stained with a green chlorite-like decomposition product, while there is also a certain amount of secondary calcite. Occasionally one notices a phenocryst of augite about 0·6 mm. in width.

The rock numbered 21-118, a dark grey compact fragment, with rough fracture, non-vesicular, showing numerous porphyritic and glomero-porphyritic labradorites, resembles some of the most basic forms of Deccan trap basalt.

The three rocks above described recall the Deccan trap, owing to the absence of olivine. The rock numbered 21-130 is a black compact basalt constituted by augite, labradorite, and iron ore, very much in the same manner as the rock just described, only with

**Olivine basalt.**

smaller elements; the chief point worthy of notice is the occasional presence of small idiomorphic porphyritic crystals of fresh olivine up to 0·4 mm. in diameter. The specific gravity of this rock is 2·97.

***Exceptional Basalts.***—The next rocks, numbered 21-141 and 21-123, are rather exceptional.

**Augite-rock with vacuoles occupied by felspar and epidote.**

The rock numbered 21-141 resembles at first sight an ordinary vesicular basalt, in which the cavities have been secondarily filled by some white mineral. These approximately spherical geodes are from 1 millimetre to 2 millimetres in diameter, and are profusely scattered through a grey-coloured base too fine-grained to be resolved into its constituent elements by an ordinary lens. In addition to the geodes filled with the white mineral there are some vacuoles of about the same size partly coated with transparent prismatic crystals of green epidote. Sometimes this same epidote is associated with the white opaque mineral which completely or nearly completely fills the majority of the globular cavities. When the white crystals do not entirely fill the cavities, they show distinct crystal terminations. The examination of thin sections under the microscope reveals a very abnormal rock. The base is made up of small prismatic crystals of augite averaging 0·1 to 0·2 mm. in dimension, together with a certain proportion of iron ores and a green fibrous serpentinous substance in the interstices between the crystals. The globular cavities are coated with a very thin film about 0·01 mm. thick, consisting of a fibrous serpentinous substance, green by transmitted light, which appears to be a devitrified glass. It is the same substance that fills the interstices between the augite crystals of the base. The white mineral occupying the globular cavities consists of felspar, which must have solidified subsequently to the augites and even after the glass of the base. The matrix is devoid of felspars, just as the geodes are devoid of augite. The fibrous serpentinous substance does not represent reaction rims, for it is observed not only between the felspar and augite, but also amongst the augite crystals, and occasionally occurs also as a lining to empty cavities.

Of the minerals that occupy the cavities, the felspars have crystallised in irregular aggregates without any distinct radial disposition, the epidotes in beautiful radiating aggregates. The average length of the felspar prisms is about 0·1 mm. They occasionally

show twin lamellation, and, judging from the angles of extinction, they appear to be some form of labradorite. Sometimes the cavities contain one of the two minerals; at other times both mineral occur together, in which case one observes that the epidotes have crystallised subsequently to the felspars. Sometimes zeolite has filled a space that had remained vacant subsequently to the formation of both the felspar and epidote.

The specific gravity of this curious rock is 2·96.

The next rock, 21-123 (Plate 34, fig. 2), which might be described as an olivine-porphyry, includes the ordinary constituent minerals of basalt, that is olivine, augite, plagioclase and iron ore. The porphyritic crystals consist almost entirely of olivine, a stray individual of augite being also occasionally observed. The conspicuous olivine crystals are embedded in a black or dark grey stony base too fine-grained to be resolved into its constituent minerals by means of an ordinary lens.

**Olivine-porphyry.**

The specific gravity is 3·08.

The porphyritic crystals of olivine constitute about one-third in bulk of the rock. They have the shape of stumpy prisms often with pyramid-like terminations, their commonest dimension being about 2 millimetres, while there are also smaller crystals, and a few larger ones occasionally more than a centimetre in length. The mineral is transparent, of a gum-like appearance and pale yellow colour slightly tinged with green. It is quite colourless in thin sections. It is practically unaltered, but traversed by numerous conchoidal cracks, sometimes lined with a thin film which appears green under the microscope. These films often appear beautifully iridescent in the hand specimen.

The groundmass consists of excessively minute elements, but under high powers the structure appears to be, on a very minute scale, the usual one of a basalt, the rock consisting wholly of crystallised minerals without any interstitial glass. The constituent minerals are augite and plagioclase in approximately equal proportions, and a rather large proportion of iron ore, perhaps $\frac{1}{20}$ of the mass of the base. The augite and plagioclase constitute minute prisms without any distinct tendency towards an ophitic mode of intergrowth. Occasionally the augite crystals are aggregated into globular patches of about 1 mm. in diameter in which the

component grains are of the usual size, but unaccompanied by any felspar.

The rock labelled 21-124 is almost identical with the one just described, except that the porphyritic augites are more numerous. The felspars and augites constituting the chief elements of the base are not so minute as in the previously described rock, the average dimension of the augite grains being 0·1 mm. The grains of iron ore are proportionately larger than in the previous rock, but the total amount of this mineral is somewhat less. The specific gravity is 3·04. The olivines in this rock are not iridescent.

This is the rock mentioned by Captain Lloyd as a "porphyritic dolerite of medium grain," and it is evidently a member of the older set of volcanics upon which the "massive lava" rests unconformably, and which there is every reason to regard as the local representative of the Deccan trap.

***Minerals from geodes in the basalts.***—In connection with these basalts, mention should be made of large specimens of agate, quartz, chalcedony, jasper, chert, opal and calcite, wholly similar to those scattered all over the areas of Deccan trap in India and, like them, evidently derived from large spherical geodes, or irregular fissures. The red hæmatitic hornstone 21-174 is a substance seldom met with in connection with the peninsular Deccan trap, but very common amongst its extra-peninsular representatives in the Arakan Yoma, the Andaman Isles, and Balúchistán and Persia.

The agates and jaspers have evidently been picked up lying loose on the ground, as is usually the case with the specimens from the peninsular Deccan trap. The large calcite specimen, 21-122, is still adhering to a fragment of vesicular basalt, much impregnated with calcite and rather decomposed, in which the only minerals still recognisable are the felspars.

## *Sandstones.*

The majority of the sandstones from the Dala region are whitish to pinkish rocks consisting of quartzose elements. The quartz is not of volcanic origin. The rocks are either fine grained, with elements not exceeding 1 millimetre in diameter, or else they pass into a conglomerate of small pebbles, the largest among which do not greatly exceed 1 centimetre.

From the constitution of the above-mentioned rocks, it is not possible to make out their stratigraphical relations to the volcanics. In one instance, however (21-158), the quartz grains are associated with numerous volcanic fragments of various sizes, the rock being intermediate between a normal sandstone and a volcanic breccia, and there is no doubt that this particular rock must be contemporaneously interbedded with the volcanic strata.

Probably, too, of volcanic origin are certain grey sandstones consisting of small angular grains of quartz scattered through a dust-like material (specimen 21-155).

## THE SALEIK COLLECTION.

The specimens from Saleik are less numerous than those from Dala, but consist of a similar assemblage of forms.

They include the following rocks:—

Devitrified rhyolite (21-165).
Brecciated rhyolite (21-166).
Altered basalts or andesite basalts (21-167, 170).
Agate and "green earth" from a geode (21-172).
Sandstone with volcanic material (21-168).
Ordinary sandstones (21-171, 173).

### *Acid Rocks.*

The devitrified rhyolite numbered 21-165 is a compact spherulitic rock with subconchoidal fracture and stony or slightly resinous lustre. The more or less confluent spherules, about 1 cm. in diameter, of white and purplish colour, scattered through a dark greenish grey, base with occasional red spots, give to the material a mottled appearance. The specific gravity is 2·57. Examined in thin slices under the microscope it appears obscurely crystalline and, to a large extent, isotropic, with a very evident streaky flow-structure, the lines of flow encircling a few orthoclase phenocrysts averaging about 1 millimetre in length. These crystals are scattered at very distant intervals and are not at all conspicuous in the hand-specimen, where they appear as small pink patches showing the characteristic pearly cleavage of the mineral.

The single specimen of a brecciated rhyolite, 21-166, is partly impregnated with secondary calcite, giving a peculiar sheen to some

of the fracture surfaces, but otherwise presents no features of special interest.

### *Basic Rocks.*

The representatives of the basic group in the Saleik collection, so far as can be made out from the altered condition of the specimens, appear to belong to the highly felspathic variety of basaltic rocks such as commonly occur in the Deccan trap of India. There is no recognisable mineral other than the plagioclase felspars, and these are so much altered and of such small dimensions that they cannot be accurately referred to any particular species. The low specific gravity points to a class of rocks intermediate between andesite and basalt, but this may be merely a consequence of their decomposed condition and vesicular structure. The specimens are greatly impregnated with secondary calcite.

One of the specimens, 21-167, is a rusty-red rock with a sharp line of separation dividing it into two portions, one of which is crowded with small vesicles about 1 mm. in diameter, while the other is more compact. The specific gravity, so far as can be made out in such a porous material, is 2·69. The rock is extremely fine-grained and probably cryptocrystalline, and so obscured by decomposition products when seen in thin sections, that a microscopic examination fails to reveal any distinct features.

The rock 21-170, with a specific gravity of 2·68, has the appearance of a greyish-lilac basalt crowded with spheroidal masses of "green earth" representing infilled vesicles. These spherules average 5 mm. in diameter and constitute about one-third in bulk of the rock. Examined in thin sections under the microscope, the rock is found to consist essentially of closely felted elongated plagioclase prisms, averaging 0·15 mm. in length. The interstices between the plagioclase prisms frequently exhibit outlines suggesting the shape of minute augite prisms, but the original material has been entirely replaced by secondary calcite. There are also outlines indicating the former existence of porphyritic crystals averaging 0·5 mm. in diameter, which may have been either augite or olivine or both, but these are entirely replaced by decomposition products.

The glauconitic "green earth", which principally occupies the large vesicles, appears, in thin sections, either milky or opaque or else translucent, in which case it shows, between crossed nicols, a minute mosaic of radiating tufts with fairly low double refraction. Calcite and chalcedony also partly fill the vesicles.

### *Sandstones.*

Amongst the sandstones from Saleik there are some fine-grained green rocks made up of very angular fragments, of which about half are ordinary quartz grains of non-volcanic appearance, while the remainder are of volcanic origin, largely fragments of crypto-crystalline rhyolite. They also include opaque grains of iron ore with metallic lustre. The specific gravity is 2·70.

The remaining sandstones are ordinary white or pink quartzose rocks varying from a fine-grained material to a pebble-bed.

## Rocks from the Aden Volcano.

The specimens from the pleistocene volcanic formation of Aden include a fragment of a friable red ash, and some dark more or less vesicular olivine-andesite-basalts or basic andesites. The specimens are too few to add anything to General McMahon's description of a much larger collection published in the *Records of the Geological Survey of India*, Vol. XVI, pages 145—158.

## Minerals of Commercial Value.

The collection does not contain any metallic ores. Limestones of good quality appear to occur abundantly in the Jurassic series. Some of the compact bright-green ash-beds, if available in large blocks or slabs, would constitute a handsome decorative material.

# NOTES ON UPPER JURASSIC FOSSILS COLLECTED BY CAPTAIN R. E. LLOYD NEAR ADEN. BY G. H. TIPPER, M.A., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 35 and 36.)

THE fossils which form the subject of these notes occur in a hard, black, distinctly carbonaceous limestone. They are generally badly weathered and the shell substance has been replaced by crystalline calcite covered with a thin film of dark brown iron oxide. It seems to be this film which has preserved the outline in many cases. It is impossible to develop them in any way, and their determination is a matter of considerable difficulty.

From the similarity of the matrix and the state of preservation of the fossils, there is little doubt that all of them, with one exception, are from the same deposit. The exception is an indeterminable fragment of an ammonite (*Perisphinctes ?*) in a light greyish limestone. It is a water-worn boulder and the matrix is so dissimilar from that of the rest that it is obviously from quite a different deposit.

The only paper with which I am acquainted dealing with Jurassic fossils from Arabia is one by Messrs. R. B. Newton and G. C. Crick entitled "On some Jurassic Fossils from Arabia", in the *Annals and Magazine of Natural History*, series 8, Volume 2, No. 7, pp. 13—30, Pls. 1—3.

In this paper a collection of fossils made by Major Hazelgrove in the Aden Hinterland is described.

These fossils are so very similar to those under discussion that the determinations and correlations suggested are of great importance. The following species are identified :—

1. *Parallelodon egertonianum* Stol. sp.
2. *Nucula cuneiformis* Sow.
3. *Trochus arabiensis* R. B. N.
4. *Nerinea* cf. *desvoidyi* d'Orb.

5. *Nautilus* cf. *hexagonus* Sow.
6. *Perisphinctes* cf. *torquatus* Sow. sp.
7. ,, cf. *subdolus* Font.
8. ,, cf. *abadiensis* Choff.
9. *Perisphinctes* cf. *Pottingeri* Sow. sp.
10. *Oppelia ?* sp.
11. *Belemnites* cf. *hastatus* de Blnv.

Newton concludes that the lamellibranchs and gastropods point to an age later than Bathonian, probably Sequanian, and that they may be correlated with the Spiti shales and certain deposits in Kutch (Kachh) on the one hand and with the Bihin limestones on the other. The material on which Crick bases his conclusions is in a very bad state of preservation, being generally compressed and weathered, while in no case are the sutures visible. It certainly seems to me that the suggested identifications are somewhat far-fetched and that the ammonites are not sufficiently well preserved to admit of an exact correlation of the Arabian deposit with those of any other region.

The following are the notes on Captain Lloyd's fossils :—

### **Belemnites** cf. **tanganensis.** Futterer. Plate 35, figs. 2 and 3.

*Zeit. d. g. Gesell.*, xlvi, p. 30, Pl. 5, figs. 2 and 3.

There are a number of fragments which obviously belong to the same species of belemnite. The characters agree so well with those of *B. tanganensis* that they are extremely closely allied, if not specifically identical. The rostrum is moderately long, slender, sub-hastate. The canal is somewhat deep and broad and runs almost the whole length of the rostrum, not quite reaching the apex. The cross-section is oval, flattened on the furrowed side, but rounded on the opposite side. Futterer says that this species has no near relative amongst the Indian Jurassic belemnites, and I have, by direct comparison with Waagen's types, been able to satisfy myself that such is the case.

This specimen differs completely from that figured by Crick. *Ann. & Mag. Nat. Hist.*, ser. 8, Vol. 2, Pl. 2, f. 1, also from near Aden.

## AMMONOIDEA.

### Genus: **Perisphinctes** Waagen.

Without exception all the ammonites collected can be referred to this genus. They form the major part of the collection and are so badly preserved that they cannot be identified. They have divided into groups according to character of the ribbing.

### Perisphinctes sp. No. 1. (Plate 35, fig. 2.)

Ribs regular, somewhat sharp, fairly widely spaced and only slightly bent forward. Ribs bifurcate and trifurcate at about half the distance between the ventral border and the shoulder. There are no well-marked nodes at the bifurcating points. Whorls rounded.

This specimen has not suffered quite so much compression as the other ammonites. Its resemblance to the specimen identified by Crick as *P. cf. abadiensis* Choff., *loc. cit.*, Pl. III, f. 2, may be pointed out.

### Perisphinctes sp. No. 2. (Plate 35, fig. 1.)

Ribs numerous, close set, sharp, almost straight, bifurcating regularly at a point a little over half the distance from the ventral edge to the shoulder, the bifurcations forming a regular V-shaped continuation with the main rib. This character is seen at one point only in the inner whorl.

### Perisphinctes sp. No. 3. (Plate 36, figs. 1, 2, and 2*a*.)

A very compressed fragment. Ribs sharp, widely spaced, regular, bent forward, bifurcating at about half the distance from the ventral edge to the shoulder. Slight nodes at the bifurcation point. The resemblance to the specimens identified by Crick as *P. cf. torquatus* Sow. sp. may be pointed out.

### Perisphinctes sp. No. 4.

Ribs straight, sharp, bifurcating near the ventral edge of the whorl. Very badly compressed fragments.

## GASTROPOD.

Genus et species indet. (Plate 36, fig. 7.)

Four specimens of a fusoid shell are represented in the collection. The spire is long, narrow and acuminate. The whorls, increasing regularly in size, are ornamented by transverse nodes and fine spiral lines which are particularly noticeable on the lower part of the whorls. The aperture is unfortunately not complete. It is prolonged into a moderately long inferior canal, the full extent of which is not seen. The inner lip is thickened and reflexed. The outer lip is broken. Probably this shell belongs to one of the fusus-like winged genera and the wings have been broken off. In shape and ornamentation it greatly resembles *Dicrolema* (*Piettia*) *seminudum* Heb. & Desl. sp., figured by Cossmann, Essais de Paléoconch., Vol. VI., Pl. IV, f. 1.

## LAMELLIBRANCHIATA.

### Parallelodon egertonianum Stol. sp. (Plate 35, fig. 1.)

Three specimens which show the characteristic ornamentation of this species are represented in this collection. Stoliczka who founded the species assigned it to the Lower Oolite. Recently while examining collections made in Thibet by my colleague, Mr. Hayden, I came across several specimens of this lamellibranch associated with *Stephanoceras humphresianum* Sow. sp., so that it is obviously one with a long range in time.

### Pinna sp. (Plate 36, fig. 5.)

A single broken specimen showing portions of both valves is represented in the collection. The ornamentation consists of irregularly spaced wavy ribs crossed at right angles by numerous fine lines. In its type of ornamentation it resembles *P. ledonica* de Loriol, "Etude sur les mollusques et brachiopodes de l'Oxfordien superieur et moyen du Jura ledonien," 3$^{me}$ partie, *Mem. Pal. Soc. Suisse*, Vol. XXXI, Pl. XXIII, f. 3. It differs very considerably in size and shape. I have not been able to find any Pinna quite like this Arabian form.

**Trigonia sp.** Group of Costatæ. (Plate 36, fig. 6.)

The ribs are fairly widely spaced and ten in number. They do not run quite to the carina, but are separated from it by a slight groove. The posterior portion of the shell is obscured by matrix and cannot be got at.

It shows considerable likeness to *T. brevicostata* Kitchin, Jurassic Fauna of Cutch, *Pal. Ind.*, ser. IX, Vol. III, pt. II, the Lamellibranchiata, Genus Trigonia, Pl. II, f. 4 & 5. It also resembles in ornamentation the fossil figured as *T. pulbis* var. by Douvillé, Fossiles du Choa, *B. S. G. F.*, ser. 3, t. XIV, Pl. XII, f. 14. It differs from both these shells in its relative proportions.

## Pecten (Syncyclonena) sp.

A fragment of a right valve with part of the shell substance preserved can be readily referred to this sub-genus. The ornamentation is of very fine concentric striæ of growth.

## Cardinia? sp.

A single fragment may perhaps be referred to this genus.

## CRINOIDEA.

## Pentacrinus sp.

Several stem joints occur scattered through the various specimens.

The present study does not shed much light on the age of the Arabian deposits, but I think that every one will agree that the fossils figured here have a distinctly Upper Jurassic facies.

# EXPLANATION OF PLATES.

## PLATE 35.

Fig. 1.—*Perisphinctes sp. No.* 2.

*Parallelodon egertonianum* Stol. sp.

Hinge and part of the shell shows in the left hand bottom corner.

Fig. 2.—*Perisphinctes sp. No.* 1.

*Belemnites* cf. *tanganensis* Futterer.

Fig. 3.—*Belemnites* cf. *tanganensis* Futterer.

Showing the canal not quite continuous to the apex. The extreme part of the apex is broken.

## PLATE 36.

Figs. 1, 2, 2*a*.—*Perisphinctes sp. No.* 3.

Figs. 3, 4.—*Perisphinctes sp. No.* 4.

These snow the compression which the ammonites have undergone.

Fig. 5.—*Pinna sp.*

Fig. 6.—*Trigonia sp.* group of costatae.

Fig. 7.—Gastropod. Genus et spec. indet.

# MISCELLANEOUS NOTES.

## Note on the Occurrence of Samarskite in South India.

ABOUT three years ago, some specimens of this rare mineral were presented to the Geological Museum by Mr. P. N. Bose without any details of occurrence or locality. Samarskite is also mentioned as occurring in India in the Report on the work of the Imperial Institute, 1906 and 1907, p. 33, (1908), but no locality is mentioned. Recently, Mr. R. R. Simpson, Inspector of Mines, sent a small piece for identification, and he has since been able to visit the locality. The following details of the occurrence have been abstracted from his interesting account. The mineral occurs on the mica property of Mr. R. V. Kuppaswamy Iyer in the Sankara mica mine, village Gridalur, Nellore district, Madras Presidency. The mica is, as usual, found in pegmatite, but the pegmatite is not of the usual type, the quartz, felspar and mica being segregated into large masses sharply separated from one another. There are three mica pits, the largest being about 20 feet in diameter and 50 feet deep. It is in the sides and bottom of the latter that the mineral occurs as loose blocks between the books of mica. One piece seen *in situ* seemed to occur as a stringer at the contact of the felspar and mica. The mineral occurs massive without crystalline form and in blocks of large size, a broken specimen in the collection weighing 5,448 grms. (13 lbs.). The surface is covered with a reddish brown film. It breaks with a conchoidal fracture. The freshly broken surface has a black splendent resinous lustre. The specific gravity of a clean piece is 5·74. A complete qualitative analysis by Mr. Blyth proved beyond doubt that the mineral was samarskite.

[G. H. TIPPER.]

# INDEX TO VOLUME XXXVIII.

# RECORDS

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## VOLUME XXXVIII.

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CALCUTTA:
SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.
LONDON: MESSRS. KEGAN PAUL, TRENCH, TRÜBNER & CO.
BERLIN: MESSRS. FRIEDLÄNDER UND SOHN.

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## CONTENTS.

### PART 1.



### PART 2.



### PART 3.

## PART 4.

# LIST OF PLATES, VOLUME XXXVIII.

**PLATE 18**—*contd.*

Fig. 4.—Section of *Sch. princeps* taken at some distance from the central chamber, but approximately parallel to the axis. ×12.

„ 5.—Transverse section of *Sch. princeps* cut at some distance from the central chamber. ×12.

„ 6.—Somewhat oblique section of *Sch. princeps.* ×12.

„ 7.—Shell of *Fusulina.*

**PLATE 19.**—*Fusulina uralica*, Krotow.

Figs. 1—6.—Specimens of various sizes: all natural size: fig. 4 represents a typical specimen.

Fig. 7.—Longitudinal (meridional) section of a large specimen. ×4.

„ 8.—The same. ×10.

„ 9.—Similar section of another specimen. ×10.

Figs. 10, 11 and 12.—Transverse (equatorial) sections of typical specimens of various sizes. ×10.

Fig. 8.—Illustrates a specimen with a large central chamber.

**PLATE 20.**—*Fusulina elongata*, Shumard.

Fig. 1.—Central part of a longitudinal (meridional) section of a medium-sized specimen similar to those illustrated in fig. 10. ×12.

Figs. 2—5.—Transverse (equatorial) sections of similar specimens; fig. 4 is cut at a little distance from the central chamber. ×12.

„ 6, 7.—Transverse (equatorial) sections of small specimens similar to those illustrated in fig. 11. ×12.

„ 8, 9.—Longitudinal sections of similar specimens, showing the small number of whorls. ×12.

Fig. 10.—Limestone with medium-sized specimens: natural size.

„ 11.—Limestone with small specimens: natural size.

Figs. 1 to 11 probably represent the megalospheric form.

Fig. 12.—Very large specimen (? microspheric form): natural size.

**PLATE 21.**—Figs. 1 and 3.—Typical longitudinal (meridional) sections of *Neoschwagerina craticulifera*, Schwager. Fig. 1 ×15, fig. 3 ×12.

Figs. 2 and 7.—Typical transverse (equatorial) sections of the same species. Fig. 2 ×15, fig. 7 ×11.

Fig. 4.—Characteristic longitudinal section of *N. craticulifera* cut at some little distance from the central chamber. ×20.

„ 5.—Transverse section of part of the shell of *N. craticulifera.* ×46.

„ 6.—Part of a similar section enlarged to show the perforations. ×90.

„ 8.—Transverse section of *Alveolina* (*Flosculina*) *pasticillata*, Schw., from Sind. ×12.

**PLAT 22.**—Figs. 1—4.—Longitudinal section of *Neoschwagerina primigena* nov. sp. ×17.

Fig. 5.—Transverse section of the same. ×20.

Figs. 6 and 7.—Transverse section of the same. ×17.

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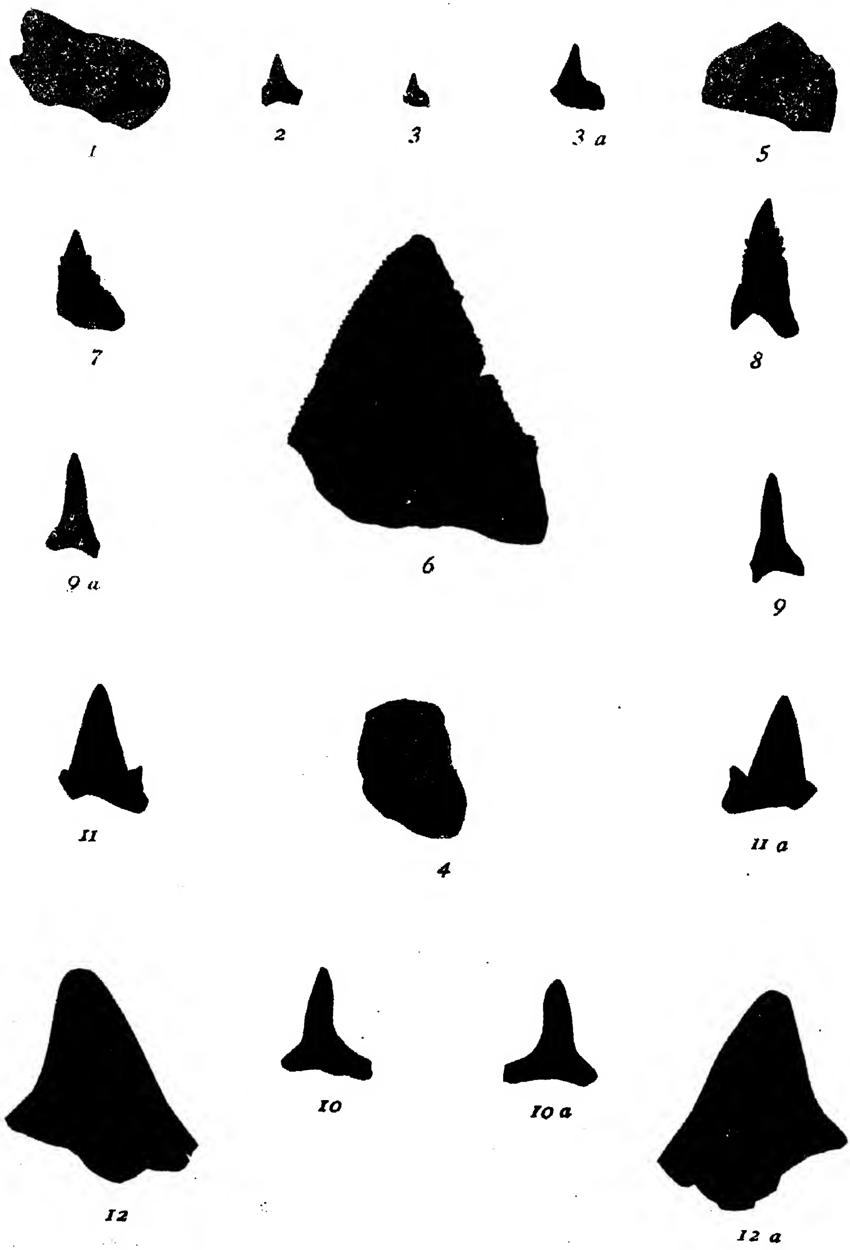



FOSSIL FISH TEETH FROM THE PEGU SYSTEM BURMA.

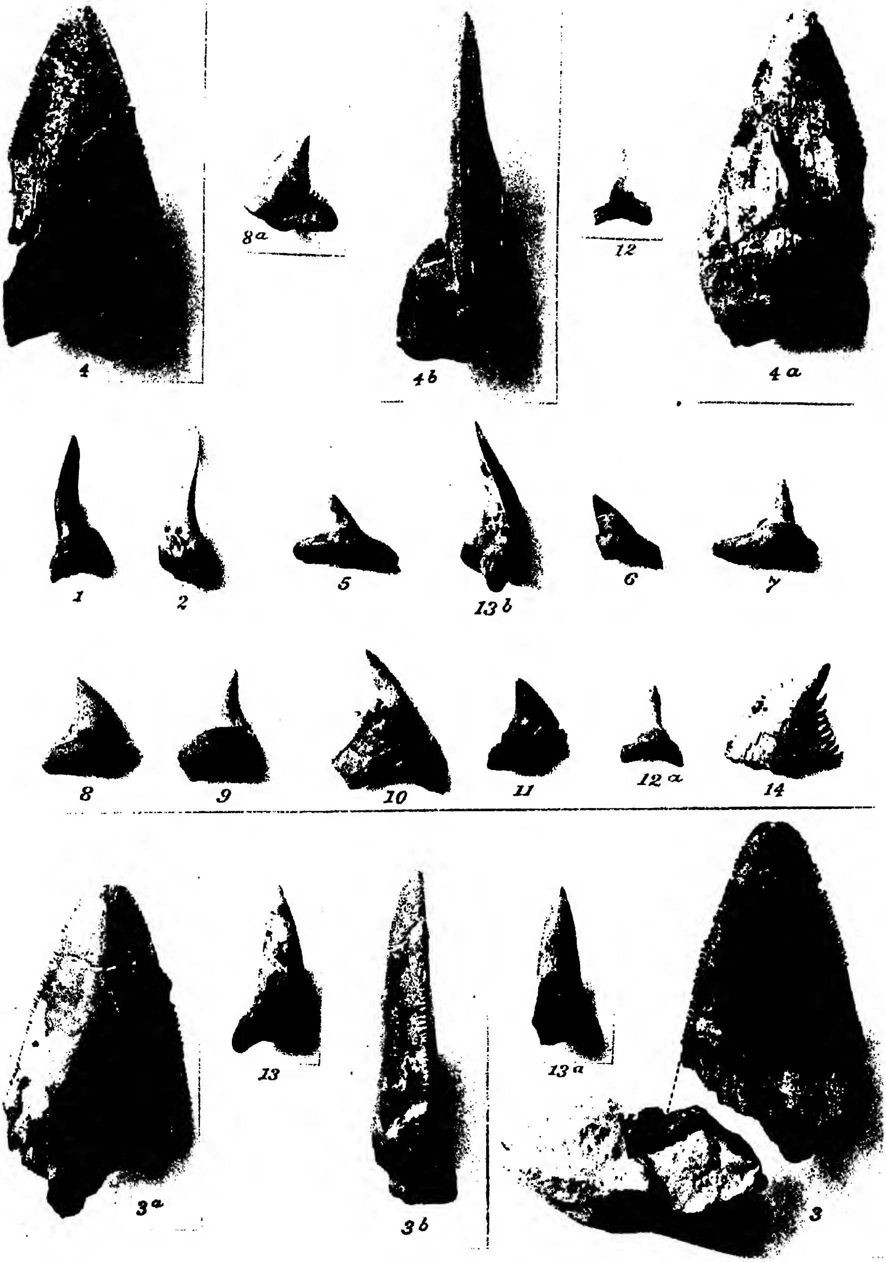
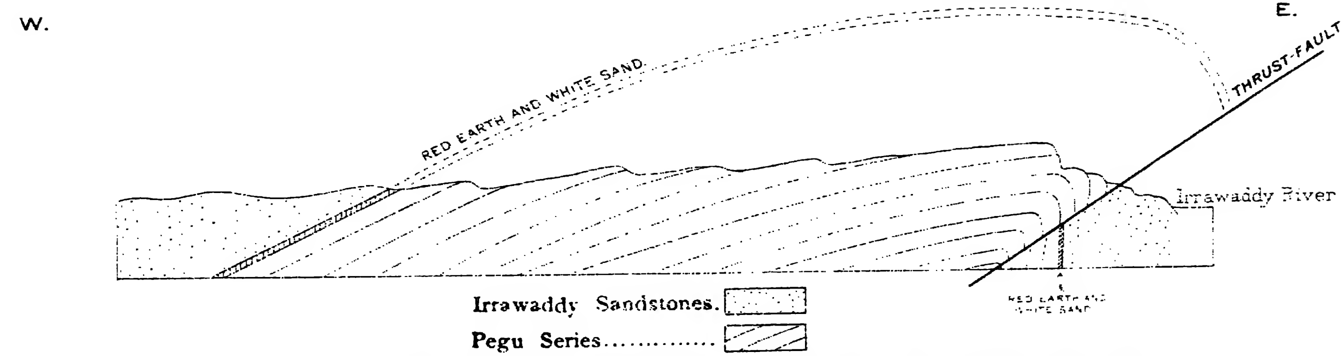



Photo. by M. Stuart — *G. S. I. Calcutta*

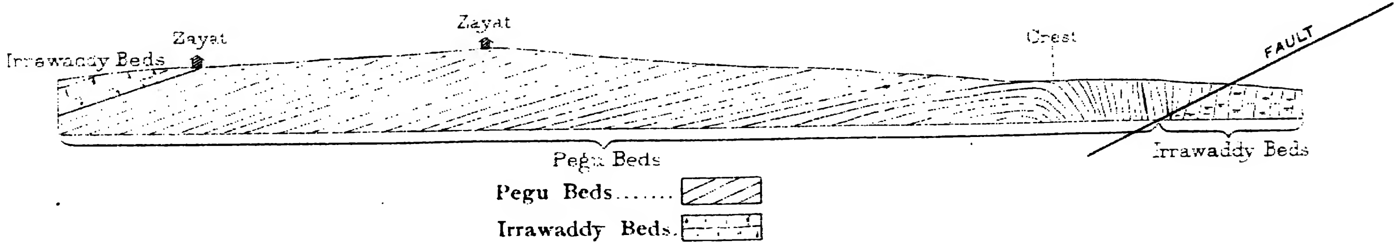
FOSSIL FISH TEETH FROM THE NEIGHBOURHOOD OF SINGU, UPPER BURMA.

Photomicrograph by M. Stuart. *G. S. I. Calcut*

VERTICAL SECTION OF HEMIPRISTIS SIMPLEX, n. sp. (?) ENLARGED 16 TIMES,

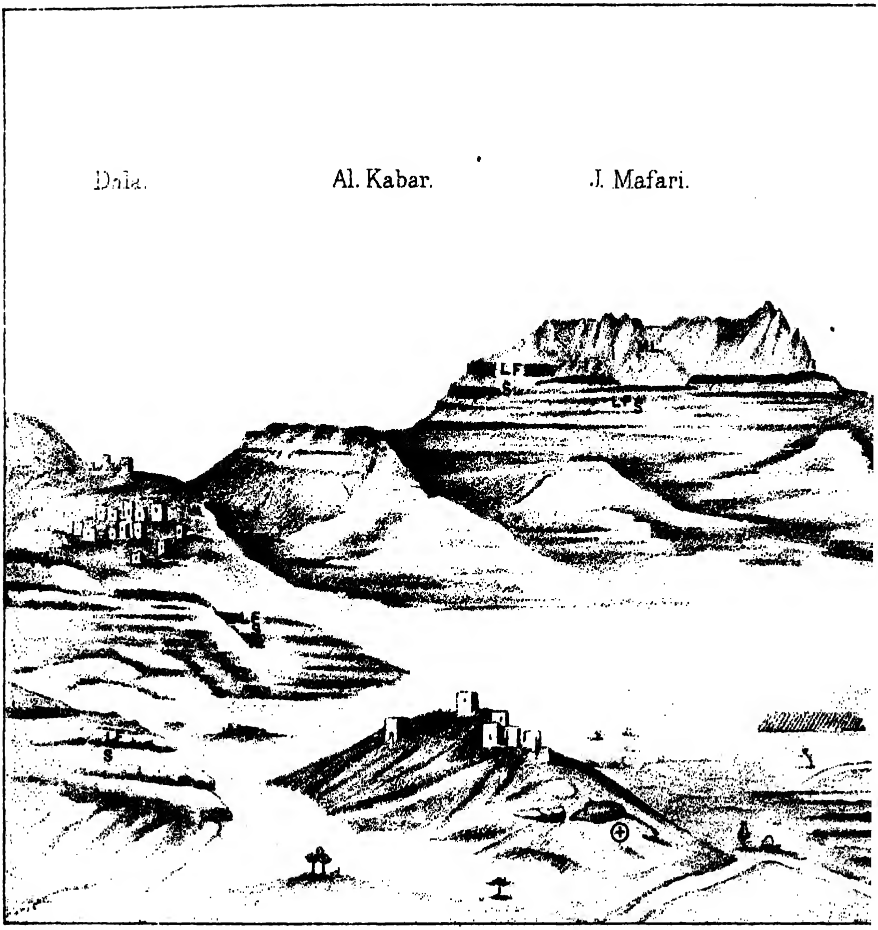



HYPOTHETICAL SECTION THROUGH THE YENANGYAT ANTICLINE, TO ACCOUNT FOR THE MISSING PEGU BEDS EAST OF THE CREST OF THE ANTICLINE.




YENANGYAT ANTICLINE; SECTION ON THE SABE—LEDAING CART-ROAD.

*Hor. Scale:— 2" = 1 m.: Var. Scale:—1" = 2000 ft.*




R. E. Lloyd del.

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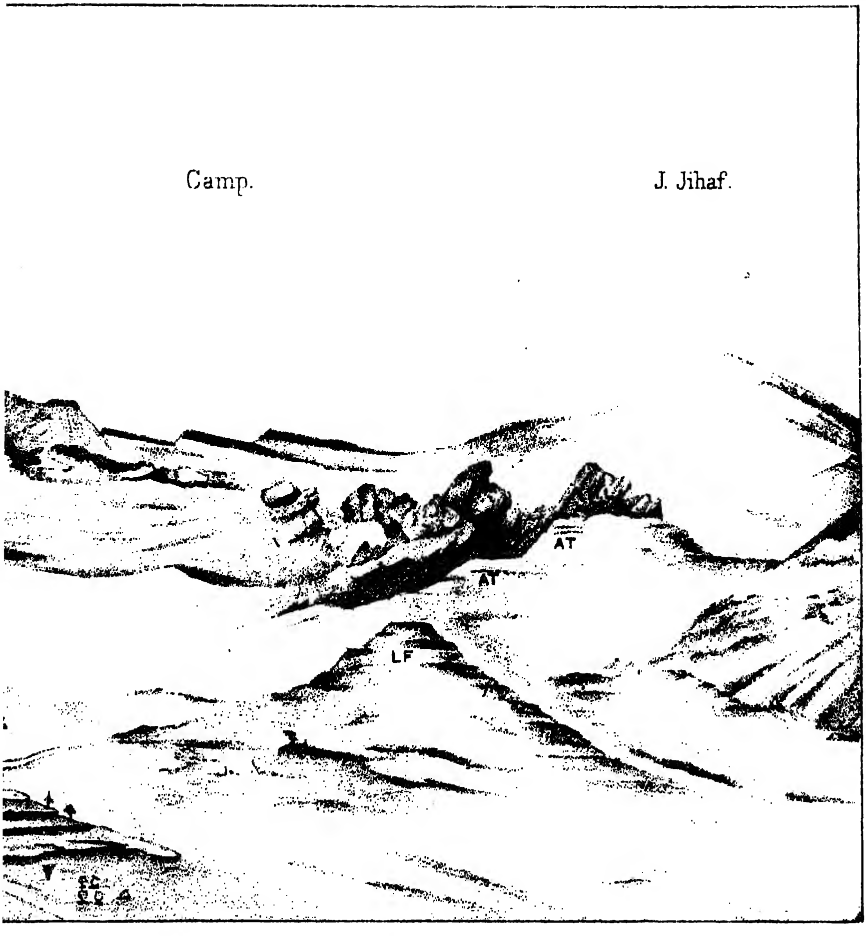
DALA AND THE NEIGHBOURING HIL

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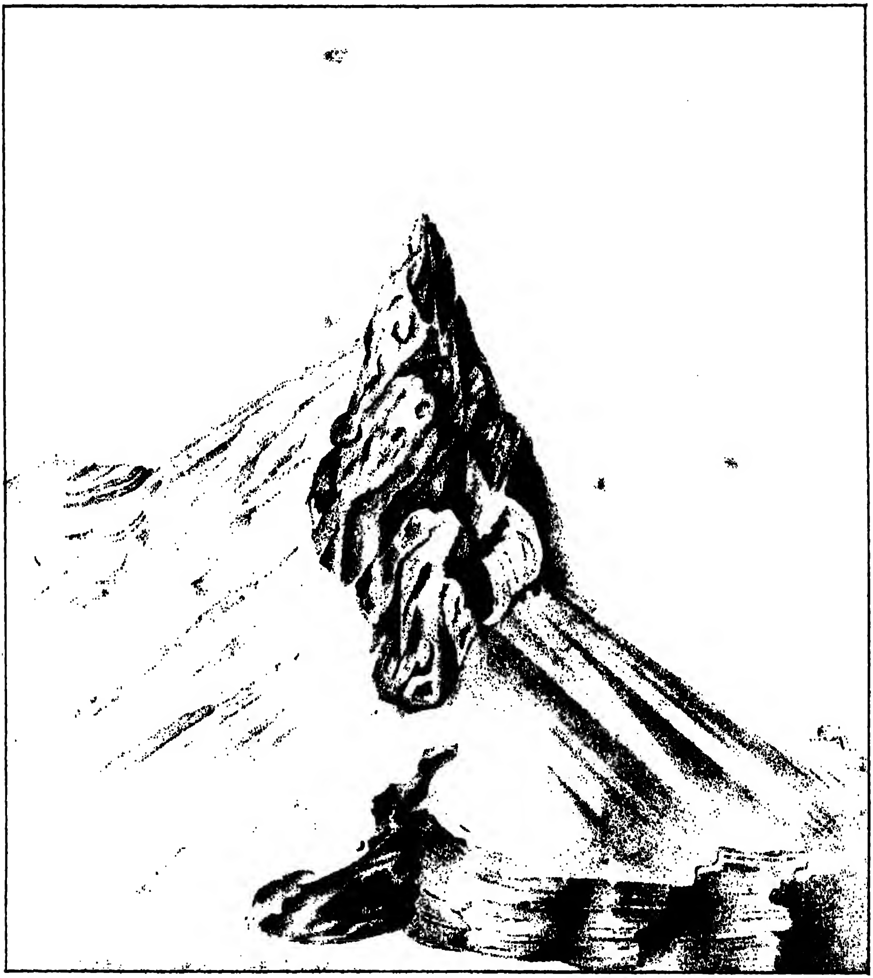
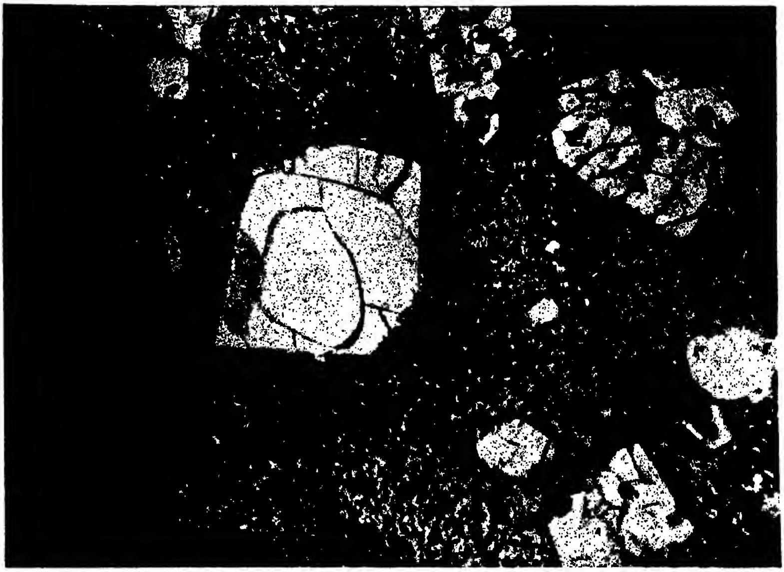
LLS, LOOKING SOUTH-WESTWARD.



R. E. Lloyd del.

PINNACLE OF "MASSIVE LAVA"
SURROUNDED BY VOLCANIC ASH-BEDS,
¼ MILE NORTH OF THE DABIYAT PLATEAU.



E. Vredenburg Phot. *G. S. I. Calcutta.*

UPPER CRETACEOUS VOLCANIC ROCKS FROM DALA NEAR ADEN.

*1. Rhyolite.– 2.– Ultra-basic lava with porphyritic crystals of olivine.*

× 20

Fig. 1. $\frac{1}{1}$

Fig. 3. $\frac{2}{1}$

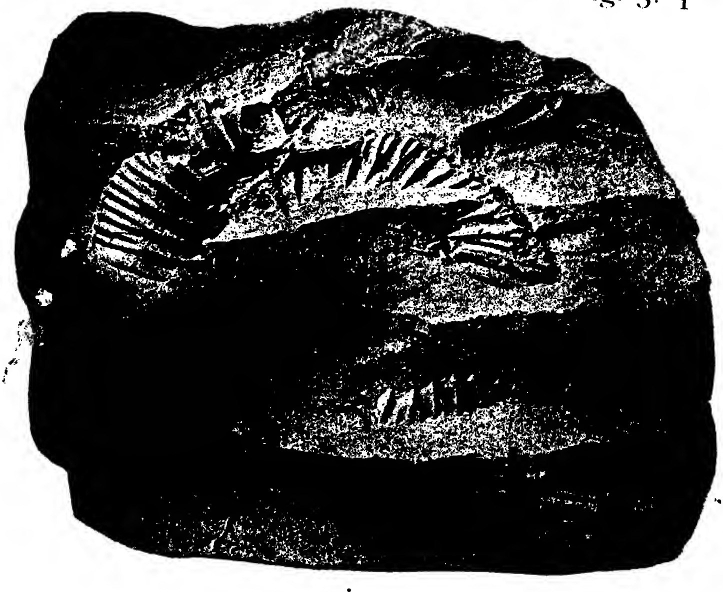


Fig 2. $\frac{1}{1}$

*2 a*

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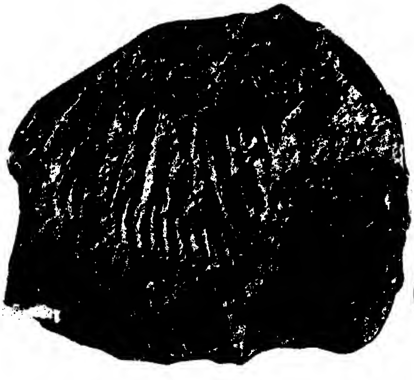

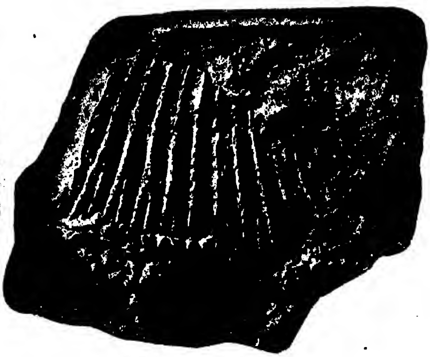

*Natural Size*

*G. S. I. Calcutta.*

*Part 2* (*out of print*).—Rocks of the Lower Godavari. 'Atgarh Sandstones' near Cuttack. Fossil floras in India. New or rare mammals from the Siwaliks. Arvali series in North-Eastern Rajputana. Borings for coal in India. Geology of India.

*Part 3* (*out of print*).—Tertiary zone and underlying rocks in North-West Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.

*Part 4.*—Geology of Mahanadi basin and its vicinity. Diamonds, golds, and lead ores of Sambalpur district. 'Eryon Comp. Barrovensis,' McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera Chœromeryx and Rhagatherium.

## Vol. XI, 1878.

*Part 1.*—Annual report for 1887. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palæontological relations of Gondwana system. 'Erratics in Punjab.'

*Part 2.*—Geology of Sind (second notice) Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.

*Part 3.*—Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

*Part 4.*—Geological distribution of fossil organisms in India. Submerged forest on Bombay Island.

## Vol. XII, 1879.

*Part 1.*—Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour through Hangrang and Spiti Mud eruption in Ramri Island (Arakan). Braunite, with Rhodonite, from Nagpur, Central Provinces. Palæontological notes from Satpura coal-basin. Coal importations into India.

*Part 2.*—Mohpani coal-field. Pyrolusite with Psilomelane at Gosalpur, Jabalpur district. Geological reconnaissance from Indus at Kushalgarh to Kurram at Thal on Afghan frontier. Geology of Upper Punjab.

*Part 3.*—Geological features of northern Madura, Pudukota State, and southern parts of Tanjore and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cretaceous fossils from Trichinopoly district, collected in 1877-78. Sphenophyllum and other Equisetaceæ with reference to Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). Mysorin and Atacamite from Nellore district. Corundum from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.

*Part 4.*—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

## Vol. XIII, 1880.

*Part 1.*—Annual report for 1879 Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia Fossil plants from Kattywar, Shekh Budin, and Sirgujah. Volcanic foci of eruption in Konkan.

*Part 2.*—Geological notes. Palæontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water-supply at Madras.

*Part 3.*—Kumaun lakes. Celt of palæolithic type in Punjab. Palæontological notes from Karharbari and South Rewa coal-fields Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana. Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1843.

*Part 4.*—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australian coal-bearing system. Reh or alkali soils and saline well waters. Reh soils of Upper India. Naini Tal landslip, 18th September 1880.

## Vol. XIV, 1881.

*Part 1.*—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north eastern Ulster, in relation to Indian laterite. Rajmahal plants Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

*Part 2.*—Nahan-Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Ossiferous beds of Hundes in Tibet. Mining records and mining record office of Great Britain; and Coal and Metalliferous Mines Act of 1872 (England). Cobaltite and danaite from Khetri mines, Rajputana; with remarks on Jaipurite (Syepoorite). Zinc-ore (Smithsonite and Blende) with barytes in Karnul district, Madras. Mud eruption in island of Cheduba.

*Part 3.*—Artesian borings in India. Oligoclase granite at Wangtu on Sutlej, North-West Himalayas. Fish-palate from Siwaliks. Palæontological notes from Hazaribagh and Lohardagga districts. Fossil carnivora from Siwalik hills.

*Part 4.*—Unification of geological nomenclature and cartography. Geology of Arvali region, central and eastern. Native antimony obtained at Pulo Obin, near Singapore. Turgite from Juggiapett, Kistnah district, and zinc carbonate from Karnul, Madras. Section from Dalhousie to Pangi, *viâ* Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

## VOL. XV, 1882.

*Part 1 (out of print)*.—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Noa-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) kaolin at Darjiling. Analyses of coal and fire-clay from Makum coal-field, Upper Assam. Experiments on coal of Pind Dadun Khan, Salt-range, with reference to production of gas, made April 29th, 1881. Proceedings of International Congress of Bologna.

*Part 2 (out of print)*.—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal-bearing rocks of Upper Rer and Mand rivers in Western Chutia Nagpur. Pench river coal-field in Chhindwara district, Central Provinces. Borings for coal at Engsein, British Burma. Sapphires in North-Western Himalaya. Eruption of mud volcanoes in Cheduba.

*Part 3.*—Coal of Mach (Much) in Bolan Pass, and of Sharigh on Harnai route between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. Traps of Darang and Mandi in North-Western Himalayas. Connexion between Hazara and Kashmir series. Umaria coal-field (South Rewah Gondwana basin). Daranggiri coal-field, Garo Hills, Assam. Coal in Myanoung division, Henzada district.

*Part 4 (out of print)*.—Gold-fields of Mysore. Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna.

## VOL. XVI, 1883.

*Part 1.*—Annual report for 1882. Richthofenia, Kayser (Anomia Lawrenciana, Koninck). Geology of South Travancore. Geology of Chamba. Basalts of Bombay.

*Part 2.*—Synopsis of fossil vertebrata of India. Bijori Labyrinthodont. Skull of Hippotherium antilopinum. Iron ores, and subsidiary materials for manufacture of iron, in north-eastern part of Jabalpur district. Laterite and other manganese-ore occurring at Gosulpore, Jabalpur district. Umaria coal-field

*Part 3.*—Microscopic structure of some Dalhousie rocks. Lavas of Aden. Probable occurrence of Siwalik strata in China and Japan. Mastodon angustidens in India. Traverse between Almora and Mussooree. Cretaceous coal-measures at Borsora, in Khasia Hills, near Laour, in Sylhet.

*Part 4.*—Palæontological notes from Daltonganj and Hutar coal-fields in Chota Nagpur. Altered basalts of Dalhousie region in North-Western Himalayas. Microscopic structure of some Sub-Himalayan rocks of tertiary age. Geology of Jaunsar and Lower Himalayas. Traverse through Eastern Khasia, Jaintia, and North Cachar Hills. Native lead from Maulmain and chromite from the Andaman Islands. Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Irrigation from wells in North-Western Provinces and Oudh.

## VOL. XVII, 1884.

*Part 1.*—Annual report for 1883. Smooth-water anchorages or mud-banks of Narrakal and Alleppy on Travancore coast. Billa Surgam and other caves in Kurnool district. Geology of Chuari and Sihunta parganas of Chamba. Lyttonia, Waagen, in Kuling series of Kashmir.

*Part 2.*—Earthquake of 31st December 1881. Microscopic structure of some Himalayan granites and gneissose granites. Choi coal exploration. Re-discovery of fossils in Siwalik beds. Mineral resources of the Andaman Islands in neighbourhood of Port Blair. Intertrappean beds in Deccan and Laramie group in Western North America.

*Part 3 (out of print).*—Microscopic structure of some Arvali rocks. Section along Indus from Peshawar Valley to Salt-range. Sites for boring in Raigarh-Hingir coal-field (first notice). Lignite near Raipore, Central Provinces. Turquoise mines of Nishápúr, Khorassan. Fiery eruption from Minbyin mud volcano of Cheduba Island, Arakan. Langrin coal-field, South-Western Khasia Hills. Umaria coal-field.

*Part 4.*—Geology of part of Gangasulan pargana of British Garhwal. Slates and schists imbedded in gneissose granite of North-West Himalayas. Geology of Takht-i-Suleiman. Smooth-water anchorages of Travancore coast. Auriferous sands of the Subansiri river. Pondicherry lignite, and phosphatic rocks at Musuri. Billa Surgam caves.

## Vol. XVIII, 1885.

*Part 1.*—Annual report for 1884. Country between Singareni coal-field and Kistna river. Geological sketch of country between Singareni coal-field and Hyderabad. Coal and limestone in Doigrung river near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

*Part 2.*—Fossiliferous series in Lower Himalaya, Garhwal. Age of Mandhali series in Lower Himalaya. Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). Geology of Chamba. Probability of obtaining water by means of artesian wells in plains of Upper India. Artesian sources in plains of Upper India. Geology of Aka Hills. Alleged tendency of Arakan mud volcanoes to burst into eruption most frequently during rains. Analyses of phosphatic nodules and rock from Mussooree.

*Part 3.*—Geology of Andaman Islands. Third species of Merycopotamus. Percolation as affected by current Pirthalla and Chandpur meteorites Oil wells and coal in Thayetmyo district, British Burma. Antimony deposits in Maulmain district. Kashmir earthquake of 30th May 1885. Bengal earthquake of 14th July 1885.

*Part 4.*—Geological work in Chhattisgarh division of Central Provinces. Bengal earthquake of 14th July 1885. Kashmir earthquake of 30th May 1885. Excavations in Billa Surgam caves. Nepaulite. Sabetmahet meteorite.

## Vol. XIX, 1886.

*Part 1*—Annual report for 1885 International Geological Congress of Berlin Palæozoic Fossils in Olive group of Salt-range. Correlation of Indian and Australian coal-bearing beds. Afghan and Persian Field notes. Section from Simla to Wangtu, and petrological character of Amphibolites and Quartz Diorites of Sutlej valley.

*Part 2.*—Geology of parts of Bellary and Anantapur districts. Geology of Upper Dehing basin in Singpho Hills Microscopic characters of eruptive rocks from Central Himalayas. Mammalia of Karnul Caves. Prospects of finding coal in Western Rajputana. Olive group of Salt-range. Boulder-beds of Salt-range. Gondwana Homotaxis.

*Part 3.*—Geological sketch of Vizagapatam district, Madras. Geology of Northern Jesalmer. Microscopic structure of Malaini rocks of Arvali region. Malanjkhandi copper-ore in Balaghat district, C. P.

*Part 4 (out of print).*—Petroleum in India. Petroleum exploration at Khátan. Boring in Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Nammianthal aerolite. Analysis of gold dust from Meza valley, Upper Burma.

## Vol. XX, 1887.

*Part 1.*—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jaunsar-Bawar and Tiri-Garhwal. Geology of Garo Hills. Indian image-stones. Soundings recently taken off Barren Island and Narcondam Talchir boulder-beds. Analysis of Phosphatic Nodules from Salt-range, Punjab.

*Part 2.*—Fossil vertebrata of India. Echinoidea of cretaceous series of Lower Narbada Valley. Field-notes: No. 5—to accompany geological sketch map of Afghanistan and North-Eastern Khorassan. Microscopic structure of Rajmahal and Deccan traps. Dolerite of Chor. Identity of Olive series in east with speckled sandstone in west of Salt-range in Punjab.

*Part 3.*—Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section I. Geology of Simla and Jutogh. 'Lalitpur' meteorite.

*Part 4.*—Points in Himalayan geology. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section II. Iron industry of western portion of Raipur. Notes on Upper Burma. Boring exploration in Chhattisgarh coal-fields. (Second notice). Pressure Metamorphism, with reference to foliation of Himalayan Gneissose Granite. Papers on Himalayan Geology and Microscopic Petrology.

## Vol. XXI, 1888.

*Part 1.*—Annual report for 1887. 'Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section III. Birds'-nest of Elephant Island, Mergui Archipelago. Exploration of Jessalmer, with a view to discovery of coal. Facetted pebble from boulder bed ('speckled sandstone') of Mount Chel in Salt-range, Punjab. Nodular stones obtained off Colombo.

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## Vol. XXII, 1889.

*Part 1* (*out of print*) —Annual report for 1888. Dharwar System in South India. Wajra Karur diamonds, and M. Chaper's alleged discovery of diamonds in pegmatite. Generic position of so called Plesiosaurus Indicus Flexible sandstone or Itacolumite, its nature, mode of occurrence in India, and cause of its flexibility. Siwalik and Narbada Chelonia

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## Vol. XXIII, 1890.

*Part 1.*—Annual report for 1889 Lakadong coal-fields, Jaintia Hills. Pectoral and pelvic girdles and skull of Indian Dicynodonts. Vertebrate remains from Nagpur district (with description of fish-skull). Crystalline and metamorphic rocks of Lower Himalayas, Garhwál and Kumaun, Section IV. Bivalves of Olive group, Salt-range. Mud banks of Travancore coasts.

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## Vol. XXIV, 1891.

*Part 1.*—Annual report for 1890 Geology of Salt-range of Punjab, with re-considered theory of Origin and Age of Salt-Marl. Graphite in decomposed Gneiss (Laterite) in Ceylon. Glaciers of Kabru, Pandim, etc. Salts of Sambhar Lake in Rajputana, and 'Reh' from Aligarh in North-Western Provinces. Analysis of Dolomite from Salt-range, Punjab.

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*Part 4.*—Mammalian Bones from Mongolia. Darjiling Coal Exploration. Geology and Mineral Resources of Sikkim. Rocks from the Salt-range, Punjab.

### Vol. XXV, 1892.

*Part 1.*—Annual report for 1891. Geology of Thal Chotiáli and part of Mari country. Petrological Notes on Boulder-bed of Salt-range, Punjab. Sub-recent and Recent Deposits of valley plains of Quetta, Pishin, and Dasht-i-Bedaolat; with appendices on Chamans of Quetta; and Artesian water-supply of Quetta and Pishin.
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*Part 3.*—Locality of Indian Tscheffkinite. Geological Sketch of country north of Bhamo. Economic resources of Amber and Jade mines area in Upper Burma. Iron-ores and Iron Industries of Salem District. Riebeckite in India. Coal on Great Tenasserim River, Lower Burma.
*Part 4.*—Oil Springs at Moghal Kot in Shirani Hills. Mineral Oil from Suleiman Hills. New Amber-like Resin in Burma. Triassic Deposits of Salt-range.

### Vol. XXVI, 1893.

*Part 1.*—Annual report for 1892. Central Himalayas. Jadeite in Upper Burma. Burmite, new Fossil Resin from Upper Burma. Prospecting Operations, Mergui District, 1891-92.
*Part 2.*—Earthquake in Baluchistan on 20th December 1892. Burmite, new amber-like fossil resin from Upper Burma. Alluvial deposits and Subterranean water-supply of Rangoon.
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*Part 4.*—Geology of country between Chappar Rift and Harnai in Baluchistán. Geology of part of Tenasserim Valley with special reference to Tendau-Kamapying Coal field. Magnetite containing Manganese and Alumina. Hislopite.

### Vol. XXVII, 1894.

*Part 1.*—Annual report for 1893. Bhaganwala Coal-field, Salt-range, Punjab.
*Part 2.*—Petroleum from Burma. Singareni Coal-field, Hyderabad (Deccan). Gohna Landslip, Garhwal.
*Part 3.*—Cambrian Formation of Eastern Salt-range. Giridih (Karharbari) Coal-fields. Chipped (?) Flints in Upper Miocene of Burma. Velates Schmideliana, Chemn., and Provelates grandis, Sow. sp., in Tertiary Formation of India and Burma.
*Part 4.*—Geology of Wuntho in Upper Burma. Echinoids from Upper Cretaceous System of Baluchistán. Highly Phosphatic Mica Peridotites intrusive in Lower Gondwana Rocks of Bengal. Mica-Hypersthene-Hornblende Peridotite in Bengal.

### Vol. XXVIII, 1895.

*Part 1.*—Annual report for 1894. Cretaceous Formation of Pondicherry. Early allusion to Barren Island. Bibliography of Barren Island and Narcondam from 1884 to 1894.
*Part 2.*—Cretaceous Rocks of Southern India and geographical conditions during later cretaceous times. Experimental Boring for Petroleum at Sukkur from October 1893 to March 1895. Tertiary system in Burma.
*Part 3.*—Jadeite and other rocks, from Tammaw in Upper Burma. Geology of Tochi Valley. Lower Gondwanas in Argentina.
*Part 4.*—Igneous Rocks of Giridih (Kurhurbaree) Coal-field and their Contact Effects. Vindhyan system south of Sone and their relation to so-called Lower Vindhyans. Lower Vindhyan area of Sone Valley. Tertiary system in Burma.

### Vol. XXIX, 1896.

*Part 1.*—Annual report for 1895. Acicular inclusions in Indian Garnets. Origin and Growth of Garnets and of their Micropegmatitic intergrowths in Pyroxenic rocks.
*Part 2.*—Ultra-basic rocks and derived minerals of Chalk (Magnesite) hills, and other localities near Salem, Madras. Corundum localities in Salem and Coimbatore districts, Madras. Corundum and Kyanite in Manbhum district, Bengal. Ancient Geography of "Gondwanaland." Notes.
*Part 3.*—Igneous Rocks from the Tochi Valley. Notes.
*Part 4.*—Steatite mines, Minbu district, Burma. Lower Vindhyan (Sub-Kaimur) area of Sone Valley, Rewah. Notes.

## Vol. XXX, 1897.

*Part 1.*—Annual report for 1896. Norite and associated Basic Dykes and Lava-flows in Southern India. Genus Vertebraria. On Glossopteris and Vertebraria.
*Part 2.*—Cretaceous Deposits of Pondicherri. Notes.
*Part 3.*—Flow structure in igneous dyke. Olivine-norite dykes at Coonoor. Excavations for corundum near Palakod, Salem District. Occurrence of coal at Palana in Bikanir. Geological specimens collected by Afghan-Baluch Boundary Commission of 1896.
*Part 4.*—Nemalite from Afghanistan. Quartz-barytes rock in Salem District, Madras Presidency. Worn femur of Hippopotamus irravadicus, Caut. and Falc., from Lower Pliocene of Burma. Supposed coal at Jaintia, Baxa Duars. Percussion Figures on micas. Notes.

## Vol. XXXI, 1904.

*Part 1 (out of print)*—Prefatory Notice Copper-ore near Komai, Darjeeling district. Zewan beds in Vihi district, Kashmir. Coal deposits of Isa Khel, Mianwali district, Punjab. Um-Rilong coal-beds, Assam Sapphirine-bearing rock from Vizagapatam district. Miscellaneous Notes. Assays.
*Part 2 (out of print)*—Lt.-Genl. C. A. McMahon. Cyclobus Haydeni Diener. Auriferous Occurrences of Chota Nagpur, Bengal. On the feasibility of introducing modern methods of Coke-making at East Indian Railway Collieries, with supplementary note by Director, Geological Survey of India. Miscellaneous Notes.
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*Part 4 (out of print)*—Geology of Upper Assam. Auriferous Occurrences of Assam. Curious occurrence of Scapolite from Madras Presidency. Miscellaneous Notes. Index.

## Vol. XXXII, 1905.

*Part 1 (out of print).*—Review of Mineral Production of India during 1898—1903.
*Part 2 (out of print).*—General report, April 1903 to December 1904. Geology of Provinces of Tsang and Ü in Tibet. Bauxite in India. Miscellaneous Notes.
*Part 3 (out of print).*—Anthracolithic Fauna from Subansiri Gorge, Assam. Elephas Antiquus (Namadicus) in Godavari Alluvium. Triassic Fauna of Tropites-Limestone of Byans. Amblygonite in Kashmir. Miscellaneous Notes
*Part 4.*—Obituary notices of H. B. Medlicott and W. T. Blanford. Kangra Earthquake of 4th April 1905. Index to Volume XXXII.

## Vol. XXXIII, 1906.

*Part 1 (out of print).*—Mineral Production of India during 1904. Pleistocene Movement in Indian Peninsula. Recent Changes in Course of Nam-tu River, Northern Shan States. Natural Bridge in Gokteik Gorge. Geology and Mineral Resources of Narnaul District (Patiala State). Miscellaneous Notes.
*Part 2 (out of print).*—General report for 1905. Lashio Coal-field, Northern Shan States. Namma, Mansang and Man-se-le Coalfields, Northern Shan States, Burma. Miscellaneous Notes.
*Part 3 (out of print).*—Petrology and Manganese-ore Deposits of Sausar Tahsil, Chhindwara district, Central Provinces. Geology of part of valley of Kanhan River in Nagpur and Chhindwara districts, Central Provinces. Manganite from Sandur Hills. Miscellaneous Notes.
*Part 4 (out of print).*—Composition and Quality of Indian Coals. Classification of the Vindhyan System. Geology of State of Panna with reference to the Diamond-bearing Deposits. Index to Volume XXXIII.

## Vol. XXXIV, 1906.

*Part 1.*—Fossils from Halorites Limestone of Bambanag Cliff, Kumaon. Upper-Triassic Fauna from Pishin District, Baluchistan. Geology of portion of Bhutan. Coal Occurrences in Foot-hills of Bhutan. Dandli Coal-field : Coal outcrops in Kotli Tehsil of Jammu State. Miscellaneous Notes.
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*Part 3*—Explosion Craters in Lower Chindwin district, Burma. Lavas of Pavagad Hill. Gibbsite with Manganese-ore from Talevadi, Belgaum district, and Gibbsite from Bhekowli, Satar District. Classification of Tertiary System in Sind with reference to Zonal distribution of Eocene Echinoidea.

*Part 4 (out of print).*—Jaipur and Nazira Coal-fields, Upper Assam. Makum Coal-fields between Tirap and Namdang Streams. Kabat Anticline, near Seiktein, Myingyan district, Upper Burma. Asymmetry of Yenangyat-Singu Anticline, Upper Burma. Northern part of Gwegyo Anticline, Myingyan District, Upper Burma. Breynia Multituberculata, from Nari of Baluchistan and Sind. Index to Volume XXXIV.

## VOL. XXXV, 1907.

*Part 1 (out of print).*—General report for 1906. Orthophragmina and Lepidocyclina in Nummulitic Series. Meteoric Shower of 22nd October 1903 at Dokáchi and neighbourhood, Dacca District.

*Part 2.*—Indian Aerolites. Brine-wells at Bawgyo, Northern Shan States. Gold-bearing Deposits of Loi Twang, Shan States. Physa Prinsepii in Maestrichtian strata of Baluchistan. Miscellaneous Notes.

*Part 3.*—Preliminary survey of certain Glaciers in North-West Himalaya. A.—Notes on certain Glaciers in North-West Kashmir.

*Part 4.*—Preliminary survey of certain Glaciers in North-West Himalaya. B.—Notes on certain Glaciers in Lahaul. C.—Notes on certain Glaciers in Kumaon. Index to Volume XXXV.

## VOL. XXXVI, 1907-08.

*Part 1.*—Petrological Study of Rocks from hill tracts, Vizagapatam district, Madras Presidency. Nepheline Syenites from hill tracts, Vizagapatam district, Madras Presidency. Stratigraphical Position of Gangamopteris Beds of Kashmir. Volcanic outburst of Late Tertiary Age in South Hsenwi, N. Shan States. New suidæ from Bugti Hills, Baluchistan. Permo-Carboniferous Plants from Kashmir.

*Part 2 (out of print).*—Mineral Production of India during 1906. Ammonites of Bagh Beds. Miscellaneous Notes.

*Part 3.*—Marine fossils in Yenangyaung oil-field, Upper Burma. Fresh-water shells of genus Batissa in Yenangyaung oil-field, Upper Burma. New Species of Dendrophyllia from Upper Miocene of Burma. Structure and age of Taungtha hills, Myingyan district, Upper Burma. Fossils from Sedimentary rocks of Oman (Arabia). Rubies in Kachin hills, Upper Burma. Cretaceous Orbitoides of India. Two Calcutta Earthquakes of 1906. Miscellaneous Notes

*Part 4.*—Pseudo-Fucoids from Pab sandstones at Fort Munro, and from Vindhyan series. Jadeite in Kachin Hills, Upper Burma. Wetchok Yedwet Pegu outcrop, Magwe district, Upper Burma. Group of Manganates, comprising Hollandite, Psilomelane and Coronadite. Occurrence of Wolfram in Nagpur district, Central Provinces. Miscellaneous Notes Index to Volume XXXVI

## VOL. XXXVII, 1908-09.

*Part 1.*—General report for 1907. Mineral Production of India during 1907 Occurrence of striated boulders in Blaini formation of Simla. Miscellaneous Notes.

*Part 2.*—Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind. Geology and Mineral Resources of Rajpipla State. Suitability of sands in Rajmahal Hills for glass manufacture. Three new Manganese-bearing minerals :—Vredenburgite, Sitaparite and Juddite. Laterites from Central Provinces. Miscellaneous Notes.

*Part 3.*—Southern part of Gwegyo Hills, including Payagyigon-Ngashandaung Oil field. Silver-lead mines of Bawdwin, Northern Shan States. Mud volcanoes of Arakan Coast, Burma.

*Part 4.*—Gypsum Deposits in Hamirpur district, United Provinces. Gondwanas and related marine sedimentary system of Kashmir Miscellaneous Notes Index to Volume XXXVII.

## VOL. XXXVIII, 1909.

*Part 1*—General report for 1908 Mineral Production of India during 1908

*Part 2.*—Ostrea latimarginata in Burma China clay and Fire-clay of Rajmahal Hills. Coal at Gilhurria. Pegu Inlier at Ondwe Salt Deposits of Rajputana. Miscellaneous Notes.

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VOL. XL, PART 1.

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## Vol. II, 1869.

*Part 1 (out of print).*—Valley of Poorna river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singhboom, etc. Wells at Hazareebagh. Meteorites.

*Part 2.*—Annual report for 1868. Pangshura tecta and other species of Chelonia from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.

*Part 3.*—Geology of Kuch, Western India. Geology and physical geography of Nicobar Islands.

*Part 4 (out of print).*—Beds containing silicified wood in Eastern Prome, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

## Vol. III, 1870.

*Part 1.*—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.

*Part 2 (out of print).*—Geology of Gwalior and vicinity. Slates at Chiteli, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.

*Part 3 (out of print).*—Mohpani coal field Lead ore at Sleemanabad, Jabalpur district Coal east of Chhattisgarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sudkal, near Futtijung, west of Rawalpindi Argentiferous galena and copper in Manbhum. Assays of iron ores.

*Part 4 (out of print).*—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singbhum: 1.—Copper mines of Singbhum: 2.—Copper of Dalbhum and Singbhum. Meteorites.

## Vol. IV, 1871.

*Part 1.*—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.

*Part 2.*—Axial group in Western Prome. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.

*Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.

*Part 4.*—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

## Vol. V, 1872.

*Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

*Part 2.*—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamconda districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

*Part 3.*—Maskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Prome. Geology of Bombay Presidency.

*Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eozoonal limestone of Yellam Bile.

VOL. VI, 1873.

*Part 1.*—Annual report for 1872. Geology of North-West Provinces.

*Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.

*Part 3.*—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanole field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.

*Part 4.*—Iron deposits of Chanda (Central Provinces). Barren Islands and Narkondam. Metalliferous resources of British Burma.

VOL. VII, 1874.

*Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron smelting in Raniganj field. Elastic sandstone, or so called Itacolumyte. Geological notes on part of Northern Hazaribagh.

*Part 2 (out of print).*—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. Geology of neighbourhood of Mari hill station in Punjab.

*Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.

*Part 4 (out of print).*—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

*Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talchir period. Trials of Raniganj fire-bricks.

*Part 2 (out of print).*—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.

*Part 3 (out of print).*—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Moflong, Khasia Hills.

*Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

*Part 1 (out of print).*—Annual report for 1875. Geology of Sind.

*Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of Stegodon Ganesa, with notes on sub-genus and allied forms. Sub-Himalayan series in Jamu (Jammoo) Hills.

*Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian faunæ of India and Burma.

*Part 4.*—Fossil floras in India. Osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Plesiosaurus in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

*Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus Omphalia near Nameho lake, Tibet, about 75 miles north of Lhassa. Estheria in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

# RECORDS

OF

# THE GEOLOGICAL SURVEY OF INDIA.

**Part 2.]** **1910.** **[ September**

## GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1909. BY T. H. D. LA TOUCHE, B.A., F.G.S., *Officiating Director.*

CONTENTS.

## INTRODUCTION.

THIS report contains a summary of the operations conducted by the Geological Survey of India during the calendar year 1909. In certain cases the results of these operations have already appeared in the publications of the Department, and these are only briefly referred to here. The work still in progress in Rajputana and in Burma is, however, not yet completed, and is accordingly described in somewhat greater detail.

2. The issue of the Quinquennial Review of Mineral Production for the period 1904—1908 has been considerably delayed because Sir T. Holland, who was engaged in compiling it, proceeded on leave in September, and was compelled to hand over the duty of completing it to Dr. L. L. Fermor. Moreover, the progress made by the mineral industry in this country during the period in question has so greatly exceeded that of the preceding six years, an account of which appeared in *Records* G.S.I., Vol. XXXII, Pt. 1, that not only has it taken a longer time to collect and arrange the material, but it has also been found necessary to set apart a whole volume of the *Records* (Vol. XXXIX) for its accommodation. The returns of Mineral Production for the year 1909 are dealt with briefly in the present issue of the *Records* and may be considered as a supplement to the Review. A list of licenses and leases granted for prospecting and mining in Government lands is appended.

## DISPOSITION LIST.

3. During the period under report the officers of the Department were employed as follows :—

### Superintendents.

| | |
|---|---|
| Mr. T. H. D. La Touche . | Returned to headquarters from the Salt Range, Punjab, on the 18th February 1909. Proceeded to Sikkim on the 24th March 1909 to examine copper-ore deposits and to survey certain glaciers. Returned to headquarters on the 8th July 1909. Assumed duties as Officiating Director from the 1st September 1909. |
| Mr. C. S. Middlemiss . | Proceeded to the field on the 1st March 1909 in charge of the Rajputana and Central India party and returned to headquarters on the 11th April 1909. Deputed on the 27th April 1909 to Kashmir to survey the plant-bearing beds underlying the Zewan stage of Kashmir. Returned to headquarters on the 30th October 1909. Placed in charge of the Central India party for extension of the geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana. |
| Mr. H. H. Hayden . | At headquarters in charge of office up to the 10th November 1909. Deputed to survey the coalfields of North-East Assam and left for the field on the 16th November 1909. |

### Assistant Superintendents.

| | |
|---|---|
| Mr. P. N. Datta . | Returned from Lower Burma on the 8th April 1909. Granted privilege |

leave for six weeks with effect from the 28th September 1909. Returned from leave on the 8th November 1909. Deputed to the Central Provinces for continuation of geological survey of the Chanda and Raipur districts and left for the field on the 29th November 1909.

MR. E. VREDENBURG — At headquarters as Palæontologist.

DR. L. L. FERMOR — At headquarters seeing the memoir of the Manganese-ore Deposits of India through the press and working on the results obtained from the survey of the Singhbhum district. Granted one month's privilege leave with effect from the 12th October 1909. Returned from leave on the 8th November 1909 and placed in charge of the office on the 10th November 1909. Deputed from the 1st to 16th December to the Lahore Industrial and Agricultural Exhibition.

DR. G. E. PILGRIM — Returned from the field on the 28th April 1909. Granted privilege leave for one month and 3 days with effect from the 15th September 1909. Returned from leave on the 1st November 1909. Appointed Curator on the 26th November 1909.

MR. G. H. TIPPER — At headquarters as Curator up to the 25th November 1909. Deputed on the 26th November to report on the monazite occurrences of Travancore State.

MR. H. WALKER — Returned to headquarters on the 30th April 1909. Deputed on the 6th

| | |
|---|---|
| | July 1909 to report on the site for a proposed dam on the Cauvery river, Madras. Returned to headquarters on the 24th July 1909. Granted privilege leave for 23 days with effect from the 24th September 1909. Returned from leave on the 1st November 1909. Deputed to revise the geological map of the Raniganj coalfield in conjunction with a Committee appointed by the Mining and Geological Institute of India and left for the field on the 18th November 1909. |
| MR. E. H. PASCOE | Returned from Burma on the 22nd August 1909. At headquarters preparing memoir on the Burma oil-fields. |
| MR. K. A. K. HALLOWES | Returned to headquarters on the 25th May 1909. Posted to the Burma party and left for the field on the 14th November 1909. |
| MR. G. DEP. COTTER | Returned to headquarters on the 20th May 1909. Left on the 1st August 1909 to relieve Mr. Pascoe in Burma. Placed in charge of the party for the survey of the Tertiary oil bearing regions in Upper Burma. |
| MR. J. COGGIN BROWN | Deputed again to Yunnan for Natural History explorations. |
| MR. J. J. A. PAGE | Returned from the field on the 11th July 1909. Deputed on the 17th November 1909 to survey the Dalbhum Estate, Singhbhum, with special attention to occurrences of minerals of economic value. Granted 3 months' privilege leave with effect from the 9th December 1909. |

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|---|---|
| MR. H. C. JONES | Returned to headquarters on the 17th May 1909. Granted privilege leave for 23 days with effect from the 28th September 1909. Returned from leave on the 1st November 1909. Re-posted to Central India for continuation of the survey of Gwalior State and left for the field on the 17th November 1909. |
| MR. A. M. HERON | Returned from the field on the 19th May 1909. Granted privilege leave for 23 days with effect from the 24th September 1909. Returned from leave on the 1st November 1909. Re-posted to the Central India and Rajputana party to survey the Alwar State, Rajputana, and Korana Hills, Punjab, and to report on the earthquake of the 21st October 1909 in the Sibi district, Baluchistan. Left for the field on the 20th November 1909. |
| MR. M. STUART | Returned from Burma on the 18th May 1909. Re-posted to the Burma party for the survey of the Prome and Thayetmyo districts, Burma, and left for the field on the 14th November 1909. |
| MR. N. D. DARU | Returned to headquarters on the 21st May 1909. Granted privilege leave for 3 weeks with effect from the 1st November 1909. Returned from leave on the 22nd November 1909 and re-posted to the Central India and Rajputana party to survey the Banswara State, Rajputana. |

### Chemist.

| | |
|---|---|
| Dr. W. A. K. Christie | . Deputed on the 3rd December 1909 to the Lahore Industrial Exhibition and to the Mayo Salt Mines, Khewra, to collect samples of salt. At headquarters for the rest of the period under report. |

### Sub-Assistants.

| | |
|---|---|
| S. Sethu Rama Rau | . Returned to headquarters on the 20th May 1909. Posted to the Burma party and left for the field on the 14th November 1909. |
| M. Vinayak Rao | . Returned from the field on the 6th June 1909. Deputed to collect mammalian remains in the Siwalik rocks of the Punjab under the instruction of Dr. Pilgrim and left for the field on the 14th November 1909. |

### Assistant Curator.

| | |
|---|---|
| Mr. T. R. Blyth | . On duty at headquarters throughout the period under report. |

## STUDENTS IN TRAINING.

4. The following students were under training during the year :—

G. G. Narke, M.A., holding a scholarship from the Central Provinces Administration, continued to work with Mr. Walker of the Raniganj coalfield till his scholarship terminated on the 31st March 1909. He was then appointed as a temporary Museum Assistant in the Geological Survey. On the 11th August 1909 he resigned this appointment and proceeded to England as a State Technical Scholar.

Kiran Kumar Sen-Gupta, M.A., B.Sc., a Research Scholar appointed by the Bengal Government, was deputed to study the wolfram deposits in the neighbourhood of Agarpara in the Nagpur District under the supervision of Dr. Fermor.

S. R. GHATPANDE, appointed by the Indore Durbar, continued to work with Mr. Jones in Central India, and on return from the field was trained at headquarters.

BYAS SANKAR LALL, B.A., appointed by the Marwar Durbar, continued to work with Mr. Heron on the Aravalli Series in the Alwar State and at headquarters on return from the field.

SHEO PRASAD GARGAVA, B.A., B.Sc., appointed by the Gwalior Durbar in November 1908, after being trained at headquarters, joined Mr. Jones in the Gwalior State.

LALA JOTI PERSHAD, B.A., appointed by the Kashmir Durbar in December 1908, after training at headquarters accompanied Mr. Middlemiss to Kashmir.

SYED ABDUL KARIM, B.A., was appointed by the Hyderabad Durbar in July 1909, and has been kept at headquarters for training.

5. One of the previous year's students who was found not to be sufficiently qualified for training returned to his State in March 1909. The remaining students have been favourably reported on, and one of them, Kiran Kumar Sen-Gupta, has recently been appointed State Geologist in Cochin.

## ADMINISTRATIVE CHANGES.

**Appointments.**

6. Mr. T. H. D. LA TOUCHE, Superintendent, was appointed to officiate as Director with effect from the 1st September 1909, *vice* Sir T. H. Holland on combined leave.

Dr. G. E. PILGRIM was appointed Curator with effect from the 26th November 1909.

**Promotion.**

7. Mr. E. VREDENBURG, Assistant Superintendent, was appointed to officiate as Superintendent with effect from the 1st September 1909, *vice* Mr. T. H. D. La Touche appointed to officiate as Director.

**Confirmation.**

8. The following officers were confirmed in their appointments as officers of the Geological Survey Department :—

Mr. M. STUART,
Mr. N. D. DARU.

Leave.

9. Sir T. H. HOLLAND was granted privilege leave for three months combined with furlough for one year with effect from the 1st September 1909.

Mr. P. N. DATTA was granted privilege leave for six weeks with effect from the 28th September 1909.

Dr. L. L. FERMOR was granted privilege leave for one month with effect from the 12th October 1909.

Dr. G. E. PILGRIM was granted privilege leave for one month and three days with effect from the 15th September 1909.

Mr. H. WALKER was granted privilege leave for 23 days with effect from the 24th September 1909.

Mr. J. J. A. PAGE was granted privilege leave for three months with effect from the 9th December 1909.

Mr. H. C. JONES was granted privilege leave for 23 days with effect from the 28th September 1909.

Mr. A. M. HERON was granted privilege leave for 23 days with effect from the 24th September 1909.

Mr. N. D. DARU was granted privilege leave for three weeks with effect from the 1st November 1909.

## LIBRARY.

10. The additions to the Library during the period 1st January to 31st December 1909 amounted to 3,275 volumes, of which 1,188 were acquired by purchase and 2,087 by presentation.

## MUSEUM AND LABORATORY.

Staff.

11. Mr. G. H. Tipper was Curator of the Museum and Laboratory until the end of November, when he left for Travancore to investigate the monazite sands of that state, Dr. G. E. Pilgrim taking over the duties of Curator. Mr. T. R. Blyth was Assistant Curator throughout the year and he continued to work with his customary earnestness and ability. Babu Bankim Behari Gupta, Museum Assistant for Palæontology, has continued to work creditably.

12. Dr. W. A. K. Christie, Chemist, was engaged principally in an investigation of the origin of the Rajputana salt deposits. The main conclusions arrived at have been published in a joint paper by Sir Thomas Holland and himself in the *Records* (Vol.

XXXVIII, Part 2). The enquiry into the probable duration of the resources of the Sambhar Salt Lake was continued. Besides the routine work of the laboratory a critical enquiry was made into the published methods for the determination of thorium in monazite sands in connection with the deposits in Southern India. None of the published methods tested gave reliable results; and a satisfactory separation has not yet been found. In December Dr. Christie was deputed to Lahore in connection with the Punjab Industrial Exhibition and at the end of the year was engaged in prospecting for deposits of potassium salts in the Punjab Salt Range.

13. The following students, Messrs. G. G. Narke, K. K. Sen-Gupta, S. R. Ghatpande, Byas Shankar Lal, Sheoprasad Gargava, Joti Pershad, and Syed Abdul Karim received training in the laboratory, chiefly during the recess. The work done was mainly determinative mineralogy with an occasional piece of simple analytical research work.

**Determinative and Chemical work.**

14. During the year there was a marked decrease in the number of specimens referred to the Curator for determination. The number examined was 361, compared with 767, in 1908. Of these assays and analyses were made of 39, a decrease of 28 on the previous year. This decrease can be explained as due to the increased number of trained prospectors at work in India, in consequence of which only the more complicated minerals and rocks are sent in for determination. Among the special pieces of work in the Laboratory may be mentioned the identification by Mr. Blyth of some specimens of samarskite, a rare niobate and tantalate containing uranium. This mineral is now known to occur in considerable quantity at the Sankara mica mine, Rapur taluq, Nellore district, Madras Presidency. Mr. Blyth also discovered among the Sikkim Copper minerals tetradymite and a cobalt mineral allied to cobaltite. Mr. Tipper investigated the triplite and accessory minerals from the Singar mica mines, Gaya district. Among the accessory minerals, columbite, zircon and pitchblende occur. The latter mineral which is of great importance as a source of radium, occurs as small rounded patches with aureoles of uranium ochre but never in any quantity.

**Meteorites.**

15. No meteoric fall was recorded in India during the year and there were no acquisitions by exchange.

**Museum.** 16. Dr. L. L. Fermor arranged show cases to exhibit the manganese ores of India and the rocks in which they occur.

The Museum Assistant for Palæontology arranged a series of Eocene fossils from the Paris basin and revised the collection of Lower Gondwana and Rajmahal plants.

The re-arrangement of the mineral collection and re-labelling of the rocks were continued.

Among the more interesting acquisitions to the collections may be mentioned :—

(1) A large series (58) of Russian minerals, chiefly from the Urals, through the Imperial Academy of Science, St. Petersburg, in exchange for a collection of Indian rocks.

(2) The following new minerals presented by the British Museum :—

Rinneite from Prussia.

Smithite and Hutchinsonite from Switzerland.

Harttite and Gorceixite from Brazil.

Patronite from Peru.

Tarbuttite from Rhodesia.

(3) A fine specimen of Hambergite by purchase.

## EXHIBITION.

**Lahore.** 17. Dr. L. L. Fermor prepared a series of mineralogical specimens for the Industrial Exhibition held at Lahore during the cold season 1909-1910 and was engaged for a fortnight in December in arranging it. The Chemist, Dr. Christie, also visited the Exhibition in connection with the enquiry that he is now making as regards the commercial value of the potassium salts found in the Punjab Salt Range.

## PETROLOGY.

**Rocks from Gwalior and Alwar.** 18. A large number of petrographical determinations have been made by Mr. Jones of the rocks collected by him in the Gwalior State, and by Mr. Heron of the Alwar rocks, but no types of particular interest have been found among them. A general account of these rocks is given in the section on Geological Surveys below (pp. 112,114).

**Rocks of the Aden Hinterland.**

19. Mr. Vredenburg has worked out the petrology of the rocks collected by Captain R. E. Lloyd, in the hill country north of Aden (*see* below p. 106). The assemblage of specimens from the older volcanic series, resembling that of the Upper Cretaceous formation in Baluchistan and Persia, together with their superposition upon the Jurassic rocks, leaves little doubt that they belong to the same period of volcanic activity as the Deccan Trap. The acid varieties are represented by rhyolitic lavas, rhyolite breccias and ash beds, and there are also some doubtful andesites. Among the basic rocks there are dolerites with beautiful pleochroic augites of purple colour; a dolerite closely resembling many of the dyke rocks of Deccan trap age occurring in Baluchistan; ordinary basalts without olivine, also resembling the Deccan trap; basalts with olivine, and an abnormal rock made up of a base composed of small prismatic crystals of augite, iron ores, and serpentinous material, through which are scattered vacuoles filled with felspar and epidote; and olivine porphyry. Geodes of agate, chalcedony, jasper, etc., are extremely common in the basalts, and may be picked up in large quantities on the surface as in the Deccan trap areas in India. Mr. Vredenburg's notes are published in Vol. XXXVIII, Pt. 4, of the *Records*.

## PALÆONTOLOGY.

**Palæontologist.**

20. Mr. E. Vredenburg carried on the duties of Palæontologist throughout the year and continued his researches upon the Tertiary and Cretaceous collections.

**Upper Jurassic fossils from the Aden Hinterland.**

21. The collections of fossils made by Captain R. E. Lloyd in the hill country north of Aden have been examined by Mr. Tipper, whose notes on them are published in Vol. XXXVIII, Pt. 4, of the *Records*. They consist of a Belemnite, *B.* cf. *tranganensis* Futterer; four species of *Perisphinctes*; an undetermined gasteropod closely resembling *Dicrolema* (*Piettia*) *seminudum* Heb. & Desl.; among lamellibranchs *Parallelodon egertonianum* Etol., and species of *Pinna*, *Trigonia*, *Pecten* (*Synchclonema*) and *Cardinia* ?; and a species of *Pentacrinus*. Mr. Tipper considers that the fauna described possesses a distinctly Upper Jurassic facies.

**Fusulinidæ from Afghanistan.**

22. In a paper contributed to the *Records* (Vol. XXXVIII, pt. 3), Mr. Hayden has given a description of various *Fusulinidæ* collected by him in the limestones of the Bamian valley in Afghanistan. The material described consists chiefly of well-known forms and includes *Fusulina uralica* Krotow, *F. elongata* Shumard, *Schwagerina princeps* Ehr., *Neoschwagerina craticulifera* Schw. and *N.* (*Sumatrina*) *annæ* Volz. A new species, *Neoschwagerina primigena*, is described, intermediate between *Schwagerina* (*Doliolina*) *lepida* Schw. and *N. craticulifera* and the last named fossil is shown to be dimorphic.

Mr. Hayden also made a critical examination of the nature of the shell of the *Fusulinidæ*, which he found to be composed of cryptocrystalline material identical in structure with the shell-substance of the *Porcellanea* and he pointed out that certain authors had mistaken the dark shell-wall for perforations and *vice versâ*. At the time of writing his paper, he had not seen the very important memoir by Professor Douvillé, which had previously appeared in the *Bulletin de la Société géologique de France*; he was not aware, therefore, that the latter author had come to the conclusion that the so-called perforations of *Fusulina* were in reality gaps in a net-work of varying degrees of fineness, and that this net-work was covered by a thin imperforate layer, to which attention had already been drawn by Girty. In Mr. Hayden's specimens the gaps in the net-work (' perforations ') are frequently seen to traverse this outer layer, which therefore appears to be ' perforate '. It is of course possible that this may be due to the state of preservation of the specimens and, with a view to deciding this, Mr. Hayden is at present in correspondence with M. Douvillé on the subject.

**Fossil fish teeth from Burma.**

23. Mr. Murray Stuart has described and figured a number of fossil fish teeth, collected from various localities in Burma, in Vol. XXXVIII, Pt. 4, of the *Records*. The evidence afforded by these is in favour of the classification of the Tertiary strata in Burma put forward by him in the paper noticed below (p. 110).

**Ostrea latimarginata in Burma.**

24. Messrs. Vredenburg and Stuart describe in Vol. XXXVIII, Pt. 2, of the *Records* the occurrence of *Ostrea latimarginata*, a species characteristic of the Gaj groups of Kachh and Sind, in the Yenan-

gyaung Stage of the Pegu System in Upper Burma. The fossil was discovered by Mr. H. J. Davies, Geologist to the Burma Oil Co., and throws much light upon the vexed question of the correlation of the Tertiary rocks in Burma. Mr. Stuart considers that the Kama clay, which occurs immediately above the zone of *O. latimarginata*, must represent a part of the 'Hinglaj beds' of Mekran, as defined by Mr. Vredenburg, and confirms the suggestion that a distinct unconformity separates this Kama clay from the base of the Irrawaddy System. This observation is of importance, as it accounts for the extreme divergence in the thickness of the Kama clay which, as recent surveys have shown, constitutes the main petroliferous horizon in Burma; whereas Dr. Noetling considered that at Yenangyaung the oil sands occurred at a lower horizon, *i.e.*, in the Lower Prome beds of Mr. Theobald (*see* below p. 110.)

**Hippurite-bearing limestone in Seistan.**

25. Mr. Vredenburg has described, in *Records*, Vol. XXXVIII, Pt. 3, two interesting species of *Hippurites* from a collection made in Seistan by Mr. T. R. J. Ward and Sir Henry McMahon, and gives in the same paper a geological sketch of the country. The two species of *Hippurites* described are *H. gosaviensis* Douvillé and a new species *Piron a persica* Vred., and Mr. Vredenburg considers the beds to be most probably uppermost Turonian. A large ribbed bivalve, which Mr. Vredenburg was unable to identify at the time his paper was written, has since been shown by Dr. Emil Böse of Mexico to be a species of *Chondrodonta*, a genus distinguished by the peculiar interlocking chondrophores of the hinge, and associated with shells of the Rudistæ in Europe and America. Mr. Vredenburg has consequently given the name of *Chondrodonta Bösei* to the Seistan species.

**New Tertiary Mammalian genera and species.**

26. As a result of the exploration of the Tertiary ossiferous deposits of India now being carried out by Dr. G. E. Pilgrim, with the assistance of Sub-Assistant M. Vinayak Rao, it has been found necessary to establish several new genera and species of mammals. A preliminary list of these is published in the present volume of the *Records*, Pt. 1, and full descriptions of those forms which have been determined up to the present are now in the press.

**Trias of the Himalaya. Dr. C. Diener.**

7. The examination of the Triassic fossils from the Himalaya collected at various times by the late Mr. C. L. Griesbach, the late Dr. A. von Krafft, Dr. Diener, Mr. Hayden and others has now been completed, and Dr. Diener has summed up the whole question of the distribution and correlation of the Triassic rocks in the four distinct areas from which the fossils have been obtained, *viz.*, Painkhanda, Spiti, Eastern Johar and Byans, and the exotic blocks between Malla Johár and Hundes, in an exhaustive paper which will shortly appear as Vol. XXXVI, Pt. 3, of the *Memoirs*.

The more recent researches of Hayden and von Krafft have shown that the Trias is not developed uniformly throughout the Himalaya, and that there is no 'type section' to which the development of the system in various localities can be referred. Thus the present memoir supersedes the summary of the Trias of Asia, so far as the Himalaya is concerned, published by Dr. Noetling in the *Lethæa Mesozoica* (Vol. I, Pt. 2, Stuttgart, 1905). The Triassic beds of the Himalaya were divided by him into ten cephalopod-bearing horizons thus:—

| | |
|---|---|
| UPPER TRIAS. | 10. *Sagenites* beds. |
| | 9. *Halorites* beds. |
| | 8. *Hauerites* beds. |
| | 7. *Tropites* beds. |
| | 6. *Joannites* beds. |
| MIDDLE TRIAS. | 5. *Ptychites* beds. |
| | 4. *Robustites* beds. |
| LOWER TRIAS | 3. *Stephanites* beds. |
| | 2. *Hedenstrœmia* beds. |
| | 1. *Prionolobus* beds. |

The base of the Trias was drawn above the *Otoceras* horizon, which Griesbach considered to be a passage bed between the Permian and Trias. It is now shown, however, that *Otoceras* is confined to a thin layer at the base of the Lower Trias.

The sub-division of the whole system now adopted by Dr. Diener is shown in the following table, which also indicates the variations

| SPITI. | THICKNESS. | PAINKHANDA. | THICKNESS. | BYANS. | THICKNESS. | EQUIVALENTS IN THE EASTERN ALPS. | |
|---|---|---|---|---|---|---|---|
| Megalodon limestone[1] | | Megalodon limestone | | Megalodon limestone | | Upper. | NORIC STAGE. UPPER TRIAS. |
| Quartzite series (*Spiriferina Maniensis*) . . | Feet. 300 | Quartzite series (*Spiriferina Maniensis*) | Feet 250 | Greenish black shales with sandy bands | Feet 1,000 | Middle | |
| Monotis beds (*Monotis salinaria*) . . | 300 | Anodontophora Griesbachi beds (Sagenites beds) | 160 | | | | |
| Coral limestone (*Spiriferina Griesbachi*) | 100 | Limestone with *Spiriferina Griesbachi* | 320 | | | | |
| Juvavites beds . . | 500 | Halorites beds. Nodular limestone with *Pseudomonotis Griesbachi* | 200 | | | Lower | |
| Dolomitic limestone (*Tropites cf. austriacus*) | 00 | Beds with *Halobia comata* | 800 | Tropites limestone | | Tuvalic | CARNIC STAGE. |
| Tropites shales (*Tropites cf. subbullatus*) . | 600 | | | | | | |
| Grey beds. Higher beds with brachiopods and bivalves, near base *Joannites cf. cymbiformis* | 500 | | | Grey massive limestone | | Julic | |
| Halobia limestone (*Halobia comata*) . | 150 | Traumatocrinus limestone | 25 | | | Cordevolic | |
| Daonella limestone. Higher beds with *D. indica*; near base *D. Lommeli* | 150 | Passage beds of the Shalshal Cliff . . | 10-20 | | 250 | LADINIC STAGE. | MIDDLE TRIAS. |
| Daonella shales (*D. Lommeli*) | 100 | | | | | | |
| Upper Muschelkalk (*Ptychites rugifer*) | | Upper Muschelkalk (*Ptychites rugifer*) | | *Ceratites, Ptychites, Spiriferina Stracheyi* limestone with *Rhynchonella Griesbachi*; near top *Sibirites Prahlada* | | MUSCHELKALK | |
| Bed with *Spiriferina Stracheyi* and *Keyserlingites Dieneri* | | Bed with *Spiriferina Stracheyi* and *Keyserlingites Dieneri* | | | | | |
| Nodular limestone[2]. Shaly bed with *Rhynchonella Griesbachi* | 100 | Nodular limestone. Shaly bed with *Rhynchonella Griesbachi* | 100 | | | | |
| Hedenstroemia beds (*Flemingites Rohilla*) | | Hedenstroemia beds (*Flemingites Rohilla*) | | | | CAMPIL BEDS | LOWER TRIAS. |
| Meekoceras beds (*Meekoceras Varaha*) | 10 | Meekoceras bed (*Meekoceras Markhami*) | | Chocolate limestone | 150 | SEIS BEDS | |
| Ophiceras bed (*Ophiceras Sakuntala*) | .. | Otoceras beds (*Otoceras Woodwardi*, *Ophiceras Sakuntala*) | | | | | |
| Otoceras bed (*Otoceras Woodwardi*) | . | | | | | | |
| Kuling shales . . | | Kuling or Productus Shales . . | | Kuling or Productus shales | . | PERMIAN. | |

[1] In the classification now employed by the Geological Survey of India, this term has been discarded for Stoliczka's original name 'Para stage' (see Burrard and Hayden, Geology and Geography of the Himalaya, p. 239).

[2] "Nodular limestone" of the Geological Survey of India classification.

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that occur in the three principal areas from which collections have been made.

Fifteen cephalopod-bearing horizons are distinguished by Dr. Diener, as shown in the following table. Of these three are rather doubtful, No. 5 being perhaps not an independent palæontological horizon, though *Rhynchonella Griesbachi* is confined to it; while from No. 9 only a single ammonite is known, *Joannites thanamensis*, and No. 15 is based on two fragmentary specimens of ammonites :—

| | SPITI. | PAINKHANDA. | BYANS. | EXOTIC BLOCKS OF CHITICHUN AND MALLA JOHAR. |
|---|---|---|---|---|
| NORIC STAGE. | 15. Horizon of *Trachypleuraspidites* aff. *Griffithi*.<br>14. Horizon of *Juvavites angulatus*. | 15. Horizon of *Sagenites* sp. ind.<br>14. Horizon of *Halorites procyon*.<br>13. Horizon of *Proclydonautilus Griesbachi*. | | |
| CARNIC STAGE. | 12. Horizon of *Tropites subbullatus*.<br>10. Horizon of *Joannites cymbœformis*.<br>9. Horizon of *Joannites thanamensis*. | 12. Horizon of *Mojsvarites eugyrus*.<br>11. Horizon of *Juvavites tonkinensis* and *Hypocladiscites subaratus*.<br>10. Horizon of *Joannites cymbœformis*. | 14.<br>13.<br>12. Horizon of *Tropites subbullatus* and *Halorites* sp. *aff. procyon*. | 12.<br>11. Horizon of *Cladiscites crassistriatus*. |
| LADINIC STAGE. | 8. Horizon of *Protrachyceras Archelaus*. | | | |
| MUSCHELKALK. | 7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*.<br>6. Horizon of Keyserlingites Dieneri. | 7. Horizon of *Ceratites Thuilleri* and *Ptychites rugifer*.<br>6. Horizon of *Keyserlingites Dieneri*.<br>5. Horizon of *Sibirites Prahlada*. | 7. Horizon of *Ceratites Thuilleri*. | 6. Horizon of *Monophyllites Confucii*. |
| LOWER TRIAS. | 3. Horizon of *Hedenstrœmia Mojsisovicsi* and *Flemingites Rohilla*.<br>2. Horizon of *Meekoceras Varaha*.<br>1. Horizon of *Otoceras Woodwardi*. | 3. Horizon of *Hedenstrœmia Mojsisovicsi* and *Flem. Rohilla*.<br>2. Horizon of *Meekoceras Markhami*.<br>1. Horizon of *Otoceras Woodwardi*. | 4. Horizon of *Sibirites spiniger*.<br>3. Horizon of *Hedenstrœmia Mojsisovicsi*. | 3. Horizon of *Meekoceras Joharense*. |
| PERMIAN | Horizon of *Cyclolobus insignis*. | | | |

The Lower Trias and Muschelkalk are developed almost equally well in Spiti and Painkhanda, but in Byans both divisions are not so well represented. In this area however the topmost beds contain the fauna of the *Sibirites spiniger* zone, which is probably homotaxial with that of the Upper Ceratite Limestone of the Salt Range.

In the ladinic stage a strongly marked difference in the development sets in. It is much richer in fossils and of greater thickness in Spiti than in Painkhanda, and has not yet been traced further east.

The same difference is equally prominent in the carnic deposits, which are well developed in Spiti, but are almost insignificant in Byans.

The noric deposits are divided into three sets of beds—Quartzite series, Brachiopod beds and Cephalopod beds—of which the last named are locally very rich in fossils but do not form a constant stratigraphical horizon. The lower noric beds of Byans show peculiar features, being made up of black shales of great thickness, wanting in the other districts. The upper noric beds consist everywhere of thick limestones which pass through beds of doubtful age into limestones of Middle Jurassic age, overlaid by the Upper Jurassic Spiti Shales. The base of these is marked by a very constant ferruginous oolitic layer of Kelloway age.

Dr. Diener appends to his memoir a discussion of the extension into other regions of the Indian Triassic province. He shows that the Triassic strata were deposited along the southern shore of the ancient ocean known as *Tethys*; that the fauna bears a quite distinct character which distinguishes it from those of the Mediterranean region; and that during the middle and upper Triassic periods Afghanistan was at the western limit of the province. Eastwards, on the other hand, the fauna of Himalayan type has been found in Yunnan, but that of Tongking points to a closer connection with the eastern Pacific region. To the south-east however the Indian marine Trias has been traced through the Malay Archipelago; and this region appears to have formed a connecting link between the Indian and Pacific provinces; while evidence of the extension of Himalayan elements to New Caledonia during this period has recently been obtained, so close that Dr. Diener states that "the

Trias of this island can scarcely put in a claim for being separated from the Indian Triassic province as a special faunistic district."

The memoir concludes with a brief account of the evolution of the Triassic ammonites.

## PHYSICAL GEOLOGY.

**Himalayan glaciers.**

28. During the year 1906 a number of glaciers in the North-West Himalaya were visited by officers of the Geological Survey and permanent marks were affixed to the rocks near their lower ends in order that observations on their secular oscillations might be made in future years.

**Alukthang and Zemu glaciers in Sikkim.**

This work was carried out at the instance of Mr. D. W. Freshfield, on behalf of the *Commission Internationale des Glaciers*, and has now been completed for the present by the demarcation of two of the glaciers descending from the Kinchinjunga Group in Sikkim. The observations recorded are published in Pt. 1 of the present volume of the *Records*. Marks have now been placed at, and plane-table plans made of, the ends of 14 glaciers, extending from Kashmir through Lahaul and Kumaon to Sikkim.

**Hassanabad glacier in Hunza.**

29. An interesting letter has been received from Dr. Hunter Workman giving an account of a visit in June 1908 to the Hassanabad glacier in Hunza, one of those marked by Mr. Hayden in 1906 (*Records*, Vol. XXXV, Pt. 3. p. 135). One of the boulders marked, No. 3 in Mr. Hayden's plan (op. cit. Pl. 38), had slipped down the hill some 50 or 60 feet from its former position, but Nos. 1 and 2 were *in situ*, and the inscriptions still bright and clear. Dr. Hunter Workman states that the tongue of the glacier had remained stationary since the plan was made, and had not altered appreciably in appearance.

**Kashmir glaciers.**

30. Dr. A. Neve, of the C. M. S. Mission, Kashmir, has sent us some interesting notes on the Murgisthang or Mongstong glacier in the Mustagh Range, and on the Machai (or Mechoi) glacier, near the crest of the Zoji La, on the road from Srinagar to Leh. The latter is one of the most easily accessible glaciers in Kashmir, but the ice is so buried in moraines on either side that it would be difficult to find spots on which permanent marks could be placed near the tongue. Dr. Neve

thinks that there has been scarcely any change in it during the last 25 years.

31. The Khumdum glaciers are situated on the right bank of the Shayok river near its source, and were visited in 1908 and again in 1909 by Captain D. G. Oliver, I.A., accompanied on the latter occasion by Dr. T. G. Longstaff. The chief interest of these glaciers, so far as the question of secular oscillation is concerned, lies in the fact that they all descend from lateral valleys to the bed of the river, along which runs an important trade route across the Karakoram Pass into Tibet. Thus any general retreat or advance of the ice can be easily recognised. Captain Oliver gives instances of floods caused by the advances of the glaciers completely across the bed of the river, the last occasion when this happened being in 1903. The Aktash glacier also advanced in the same manner in 1905 but caused no flood as the water percolated through sand in the river bed at this point.

**The Khumdum glaciers.**

Dr. Neve's and Captain Oliver's notes will shortly be published in the *Records*

32. While engaged on a traverse along the plateau of the Salt Range in the Punjab, for the purpose of ascertaining the probable extension of the coal seams beneath the Nummulitic limestone, I took the opportunity of surveying and taking soundings of the four permanent lakes found on the plateau. The basins of these lakes, with the exception of the Jalar Kahar, were found to owe their origin to earth movements, that is to say, to a synclinal fold in the case of the Kabaki Kahar and to faulting in that of the Kalar and Son Sakesar Kahars respectively. The Jalar Kahar has been formed by erosion along the crest of an anticlinal fold in Carboniferous limestone. All the lakes are very shallow and none of them has any visible outlet. Their present configuration is due to irregularities in the accumulation of wind-blown 'loess,' which collects in the original depressions. A full account of the lakes is published in Pt. 1 of the current volume of the *Records*.

**Lakes of the Punjab Salt Range.**

33. In a paper published in Vol. XXXVII, Pt. 3, of the *Records*, Mr. Coggin Brown brought up to date the accounts of the various eruptions of the mud volcanoes situated off the Arakan Coast that have taken place since 1893. There appears to have been a remarkable period

**Mud volcanoes off the Arakan Coast.**

of quiescence between the years 1886 and 1903, similar to that noted by Mr. Mallet between 1846 and 1878, but it is not certain that the apparent falling off in activity is not due to lack of evidence of eruption. Since 1903 five eruptions have been recorded and are described by Mr. Brown, one of which resulted in the formation of a new island, off Beacon Island, on the 15th December 1906. This island was still in existence in December 1908, but a great part of it had been washed away.

## ECONOMIC ENQUIRIES.

### Coal.

**Revision of the map of the Raniganj coal-field.**

34. The revision of the geological map of the Raniganj coal-field, undertaken in November 1908 in conjunction with a Committee appointed by the Mining and Geological Institute of India, has made fair progress, and it is hoped will soon be completed. The re-survey is being carried out on behalf of the Geological Survey Department by Mr. H. Walker, who testifies to the general accuracy of the original maps, for a long time out of print, constructed by the late Dr. W. T. Blanford in 1858-1860; only minor corrections in the boundaries along the margin of the field, where dense jungle existed in Dr. Blanford's time, being necessary. The principal additions to our knowledge of this important area have been made with respect to the underground correlation of the coal seams and the more accurate mapping of faults and dykes, in which work Mr. Walker and the Committee have received most valuable assistance from the owners and managers of the collieries, most of whom have placed their mining plans and boring records freely at their disposal.

**Gilhurria, Rajmahal Hills.**

35. A small patch of Damuda rocks at Gilhurria on the western flanks of the Rajmahal Hills, containing a seam of combustible carbonaceous shale, was examined by Mr. Stuart in the course of his examination of the area for china-clay and glass-making sands (referred to in last year's General Report) and is described in a short paper in Vol. XXXVIII, Pt. 2, of the *Records*. The occurrence is interesting, as it indicates the continuance of the Damudas of the Hura and Dhamni coal-fields beneath the trap, but the coal, which was being quarried by the natives, is of poor quality at the outcrop.

36. At the instance of the Railway Board I was deputed to visit the coal mines being worked by native owners in that part of the Punjab Salt Range which lies in the Shahpur District, as application had been made for the construction of a branch line from Dhak station on the Sind-Sagar line to the foot of the range to serve the mines. At present the mines are worked entirely from the outcrop, and no attempt has been made to form a reliable estimate of the quantity of coal available. The present output is not more than 40 or 50 tons a day, and until more capital is spent on the development and equipment of the mines, it would be premature to discuss the question of constructing a branch line to the locality, unless there is a demand for building stone from the Range sufficient to supplement the coal traffic.

**Punjab Salt Range, Shahpur District.**

I also made a traverse along the Salt Range plateau and suggested that a series of borings should be put down through the Nummulitic limestones which cover the greater part of it, in order to ascertain whether coal exists in workable quantities beneath it at the horizon at which the coal seams crop out along the southern scarp. An experimental boring at Dandot was sanctioned for the purpose of estimating the cost of carrying out this scheme, and is now in progress.

37. Reports of the discovery of coal in the valley of the Great Rangit River in Sikkim having been received, I visited the localities during my tour in that State. Several of the outcrops had been opened out sufficiently to show that the so-called coal is a dense black carbonaceous shale, so greatly crushed as to have assumed a nodular structure in which the nodules are surrounded by a thin glistening film of carbon, the appearance in bulk being that of a hard bright coal. It is so impure however that when placed on a fire it merely becomes calcined, and it will not support combustion. Some of the seams are as much as 6 feet in thickness, but none of the so-called coal is of any value as fuel.

**Sikkim.**

## Copper.

38. On my way to the glaciers of Kinchinjunga I also visited the localities in Sikkim at which copper ores are known to occur, and are now being actively prospected under European supervision. The conditions under which the lodes occur, especially the intense folding and dislocations to

**Sikkim.**

which the rocks have been subjected, render it extremely difficult to form a definite opinion regarding the continuation of any particular occurrence of ore, but it is evident that in many cases the lodes, though perhaps originally continuous, have been broken up into a succession of small detached lenticles or pockets, and that the location of these would be a matter of great difficulty and expense. In a few instances, however, lodes of some persistence have been opened up, and may prove to be worth exploitation by modern methods.

**Gwalior.**

39. Traces of copper ores in the Bundelkhand gneiss of the Gwalior State were investigated by Mr. Jones (*see* below, p. 113) but were found to be of no economic importance.

## Engineering Questions.

**Building sites at Dalhousie.**

40. At the request of General C. H. Powell, Commanding the Jullunder Brigade, I visited the Hill station of Dalhousie in September for the purpose of examining the sites proposed for the erection of a garrison church and other buildings. The cantonment is situated on a narrow spur known as the Balun spur which runs out to the north from the high ridges on which Dalhousie itself is built, at a considerably lower level than the civil station. This spur consists of slates which have a regular easterly dip, corresponding very closely with the slopes on the eastern side of the spur. The soil cap on this side, which is of great thickness, has therefore a constant tendency to creep downwards, as the toe of the slope is cut away by the stream at its base, and any heavy structures, either on the slope or near its crest, are liable to serious movement of their foundations. In fact every building already erected in such a position is severely cracked, and the eastern end of one of the barracks, which are exceedingly massive, had to be pulled down some years ago. These movements are, however, entirely confined to the soil cap, and all buildings erected not too near the eastern edge of the spur would be perfectly safe. Such a site was selected for the church and the other buildings to be erected.

**Cauvery River Project, Coimbatore District.**

41. In response to a request made by the Chief Engineer for Irrigation in Madras that the sites proposed for a dam on the Cauvery River in the Coimbatore District should be inspected and reported on by a geologist, Mr. H. Walker was deputed on this duty in July

1909. Five sites in all were examined, situated on a straight reach of the Cauvery between Cauveripuram and the mouth of the Bhavani River, where it is bordered on either side by hills of crystalline rocks. Mr. Walker submitted a full report to the Local Government, and was able to recommend a site about 3 miles below the village of Sanpalli as the most suitable for the project, but details of alternative sites are given, the final choice depending upon economic and engineering considerations.

## Fire clay.

**Gwalior State.**

42. Among the clay beds at the base of the Morar group in Gwalior State a thick bed of soft white clay near Raipur G. T. S. has been extensively mined for use as whitewash, but from its composition, and from tests made by Mr. H. C. Jones, it is considered that it would make good fire bricks.

## Galena.

**Gwalior State.**

43. Mr. H. C. Jones examined some occurrences of galena in the Gwalior State at the request of the Durbar. Mere traces of the existence of the mineral were found, as described below (p. 113).

## Petroleum.

**Burma.**

44. The Burma Oil-fields party for the field-season 1908-09 consisted of Messrs. E. H. Pascoe, G. de P. Cotter, K. A. K. Hallowes, M. Stuart and Sub-Assistant S. Sethu Rama Rau.

**Oil-fields Committee, Yenangyaung.**

45. At the beginning of the season Mr. E. H. Pascoe was engaged in assisting the Committee appointed to enquire into the working of the Yenangyaung oil-field. An analysis of data regarding flash-points and specific gravities supplied by the Burma Oil Co. led to the following interesting conclusions:—

(*i*) That in each well the specific gravity decreases generally with the depth, especially near the surface.

(*ii*) That in each oil horizon the specific gravity is generally least at the crest and increases further down the flanks of the anticline. Wells therefore near the margin of the field may be expected to yield a heavier oil at any particular horizon than those nearer the crest.

A final attempt was made to correlate the various oil sands recorded in the boring logs of the Companies engaged in the industry, but was not successful.

**Ramri Island.**
**Mr. E. H. Pascoe.**

46. The portions of Ramri Island, off the coast of Arakan, examined were the northern area including the Minbyin oil-field (Yenandaung) and the oil-field of Ledaung. The island is evidently part of a raised archipelago and raised beaches are found all along the West coast. The rocks consist of sandstone and clays with occasional thin bands of conglomerate. Calcite is abundant locally, but selenite was not found in the portions of the island visited. From Mr. Davies' find of nummulites near Pyade, some of the rocks appear to be of Eocene age. Mr. Pascoe was no more successful than Mr. Mallet in any attempt to divide the beds into distinctive series.

In all but one or two doubtful cases, the rocks are inclined steeply or vertically, and the hypothesis which fits in best with the facts is that there are several sharp contiguous folds which have been sufficiently denuded to leave an almost uninterrupted series of steep dips. Some of the folds are very sinuous, and the direction of dip and strike may vary enormously.

Mud volcanoes, gas vents and oil seepages are found throughout the island except within a barren tract around the town of Ramri.

In the Minbyin field native workers have shewn themselves more enterprising than those at Yenangyaung, and have adopted a crude method of the rod-system used in Canada, learnt from Canadian drillers employed by the Australian and Baronga Oil Companies. The wells are cased for the first 18 to 20 feet only, and are never more than 500 feet deep. Some 200 wells have been put down here but most of these have been abandoned, less than 50 being worked at the present day. The total yield of the field amounts to something under 2 barrels (80 gallons) per day.

Between 15 and 20 wells have been drilled at Ledaung about 24 miles south of Minbyin and some are still producing oil.

**Mr. G. deP. Cotter.**

47. Two areas were surveyed by Mr. Cotter—one in the Minbu district and one in the Pakokku district.

**Minbu District.**

In the Minbu district, sheets 111 and parts of sheets 110 and 84 L/6, Burma Survey, 1″= 1 m., were geologically mapped. The Pegu beds are found in the West of sheets 111 and 84 L/6, dipping very regu-

larly east except in the neighbourhood of Ngahlaingdwin where they are disposed as an anticline. Mr. Cotter was able to differentiate the Pegu beds into three groups which grade insensibly into one another. The upper group consists of shallow water deposits with current-bedded sandstones, selenite and shallow water fossils including *Cyrena crawfurdi* and *C. khodaungensis.* In the middle group, current-bedding is uncommon, the rocks are harder, the clay beds more sharply differentiated from the sands, and the fossils belong to the "laminaria" zone. The lower group resembles the middle, but the sandstones are coarser and harder and the limestone bands slightly more frequent. A species of *Heterostegina* and a nummulite, most probably of oligocene age, were found at an oil seepage 3 miles N. N. W. of Ngahlaingdwin. Another seepage occurs $3\frac{1}{2}$ miles W. S. W. of the same village. The Ngahlaingdwin anticline is steeper on the west than on the east; and since it sinks rapidly southwards in the area mapped, Mr. Cotter is of opinion that it would be well worth while to examine the area to the north in sheet 84 L/5 before testing near Nghlaingdwin.

**Pakokku District.**

In the Pakokku district the Myaing anticline was examined and surveyed with the aid of cadastral maps on a scale of 2″ = 1 m. The anticline, consisting of Pegu and Irrawaddy beds, resembles that of the Gwegyo hills. The crest is recognisable near Chaingzauk, but southwards has been faulted away by what Mr. Cotter considers to be probably a thrust-plane on the east. Fossils of the usual Pegu types were found together with selenite and fossil wood, the latter being fairly common in the Pegu rocks. There are many gas pools, but Mr. Cotter considers the area unpromising for oil boring on account of the contortion and faulting.

**Myingyan District. Sub-Assistant Sethu Rama Rau.**

48. The following sheets of the Burma Survey 1″ = 1 m. were mapped geologically: parts of 109 and 112, east of the Irrawaddy, the northern half of sheet 153, and the whole of 156.

In sheet 109 the eastern boundary of the Pegu inlier of Singu was mapped for the first time on this scale, as also was the northern part of the Gwegyo anticline and the southern extremity of the Pagan fold. Cone-in-cone structure was found in many places in the northern part of the Gwegyo anticline.

In sheet 153 the rocks east of the Popa area were found to be folded into successive sharp anticlinal and synclinal folds and

consisted of Pegu strata. The crests of the anticlines usually occupy low ground, and their direction is about 40° W. of N. to 40° E. of S. Sandstones predominate over shales, and some contain many nodules of carbonised wood enclosed in pyritiferous sandstone. Fossil bands are plentiful, the commonest species being *Turritella simplex* and *T. acuticarinata*. Specimens of *Batissa* including *B. khodaungensis* were also obtained.

The country surveyed in sheets 156 and 112 (E. of the river) is that around and east of Magwe. In it was discovered the Pegu inlier of Ondwe on which a short note has already been published (*Records*, Vol. XXXVIII, Pt. 2, p. 152) and which is shortly to be tested for oil.

**Possible oil-field in Las Bela and Southern Mekran.**

49. Mr. Vredenburg in a recent paper in the *Records* (Vol. XXXVIII, Pt. 3, p. 206), has called attention to the possibility of petroleum being found in Las Bela and the Mekran district, in rocks belonging to the Hinglaj series which correspond with the oil-bearing strata of Burma. The structure is favourable for the storage of petroleum in large quantities underground should it exist, and though no oil seepages occur, the presence of mud volcanoes along the crest of some of the anticlinal axes is a favourable sign.

The other minerals found in southern Baluchistan were noticed in the General Report for 1906 (*Records*, Vol. XXXVIII, Pt. 1, p. 50), and are described in greater detail in Mr. Vredenburg's paper cited above.

## Road-metal and Building Stone.

**Road-metal for Rangoon.**

50. Reference has been made in previous General Reports (*Records*, Vol. XXXIII, Pt. 2, p. 85, Vol. XXXV, Pt. 1, p. 30) to the question of an adequate supply of road-metal for Rangoon, the cost of importing such material from Bombay and Mauritius having become prohibitive in view of the rapid extension of the roads of the city and its surroundings and the great increase of traffic within the last few years. Formerly the Bombay basalt was brought in by ships in ballast and was collected at little cost to the Municipality, but the opening of direct steamship communication with foreign countries has cut off this source of supply. At the request of the Chief Engineer to the Government of Burma

Mr. P. N. Datta was deputed to examine the crystalline rocks of the Thatón District, Lower Burma, rendered accessible by the opening of the Pegu-Moulmein Railway, and his report, submitted in May 1909, shows that there is a practically inexhaustible supply of gneiss and granite to be obtained within easy reach of the line. These rocks, though perhaps not quite so durable as the Bombay basalt, will no doubt serve the purpose required at far less cost than the imported material.

**Taungu stone quarries.**

51. In the General Report for 1908 (*Records*, Vol. XXXVIII, Pt. 1, p. 46) reference is made to a visit by Mr. G. deP. Cotter to the stone quarries of Taungu, Lower Burma, in order to advise the Public Works Department, Burma, regarding the location of a Government quarry for the supply of building stone. Mr. Cotter's report, submitted in April 1909, shows that building stone of two qualities may be obtained in large quantities from these quarries—

(1) A yellow calcareous sandstone occurring in a bed from 200 to 300 feet thick, and extending for a mile along the strike. This is somewhat soft when freshly cut but hardens on exposure to the air.

(2) Purple, sometimes pink, sandstone of medium grain, very slightly calcareous and considerably harder than the yellow sandstone. It occurs in layers averaging about 6 inches in thickness, but slabs of one foot thick might be obtained. Other localities in the neighbourhood were visited but the stone was found to be of inferior quality.

## Salt.

**Salt manufacture. Myingyan District, Burma.**

52. The relics of a once flourishing salt manufacturing industry in the Myingyan District, now moribund on account of the competition of imported salt, are described by Sub-Assistant Sethu Rama Rau. The inhabitants of one village, Sagyin, even now subsist chiefly on this industry, and a few others are still engaged in it. The salt is derived from springs and causes a saline efflorescence on the surrounding soil. After saturation as far as possible by repeated moistening with the water flowing from the springs and drying, the soil is lixiviated either in large conical wicker baskets or in rows of earthen pots, and the brine evaporated over a slow fire.

## Water.

53. Many applications have been received from Local Governments and private individuals during the year for advice regarding the search for artesian water in various parts of India. Where these enquiries are concerned with the great expanses of alluvium that cover the valleys of the Indus, Ganges and Brahmaputra the advice of a geologist is of little value, as the alluvial strata lie horizontally and information regarding the distribution of subsoil water can only be obtained by actual experiment, that is to say by well sinking or boring. In hilly tracts on the other hand the possibility of obtaining artesian water depends entirely on local conditions and it is not often possible to ascertain these from a small scale geological map without personal inspection of the ground. The following is a summary of the work that has been done during the year.

**Baluchistan: Mastung.**

54. A boring was put down close to the Political Agent's house at Mastung to supply drinking water, and was carried to a depth of 510 feet without meeting with water under sufficient pressure to bring it to the surface. The rocks passed through, judging from the samples submitted, were Siwalik clays, with a bed of loam at 410 feet, from which water rose to between 13 and 17 feet below ground level. This water was found to be slightly brackish, but it is not clear whether the brackishness was not caused by a leak in the tube at a higher level.

**Kulozai.**

55. A boring put down to a depth of 410 feet near Said Hamid railway station (Kulozai) was not successful. It was proposed to make another attempt near Gulistan, 8 miles further to the south, where the conditions are similar to those at Quetta, and there are some "karezes." A supply sufficient for drinking purposes might be obtained here.

**Bengal: Borings for sub-soil water.**

56. Considerable activity has been shown by the Agricultural Department in Bengal in sinking borings in search of sub-soil water, in accordance with the recommendations of the Irrigation Commission. From a note supplied to this Department, by Mr. W. R. Gourlay, Director of Agriculture, it appears that operations have been carried on in nine districts, both north and south of the Ganges, and that several of the District Boards have purchased

sets of tools. The wells sunk are said to have been more successful in the districts to the south of the Ganges than to the north, as the former must be sunk to a greater depth before reaching a water-bearing stratum, and, therefore, the water rushes in with greater force. On the north side the sands lie at a shallower depth, and it will probably be found advisable to sink ordinary percolation wells in this area.

**Proposed deep boring at Sitamarhi.**

57. In April 1909 the District Engineer in Muzaffarpur, and more recently the Secretary to the Government of Bengal, Irrigation Department, requested our advice regarding the putting down of a deep boring at Sitamarhi, in order to ascertain whether water under pressure does not exist in the coarse gravel beds that presumably lie at the base of the Gangetic alluvium. In view, however, of the distance of Sitamarhi from the northern edge of the plains, whence the water would be derived; the slight elevation above the plains of the beds into which the water percolates from the hills; and the poor results obtained from the Lucknow boring, 1,336 feet deep, in 1889, I was compelled to reply that I did not think the prospects sufficiently good to warrant the expenditure of a large sum of money on a deep boring. I think that the salvation of this and neighbouring districts will consist in the deepening of existing wells, or the sinking of borings through them, in order to reach deeper water-bearing strata in the alluvium, which may keep them supplied in times of drought.

**Raniganj.**

58. Messrs. Balmer, Lawrie & Co. having reported that they experienced increasing difficulties in obtaining an adequate supply of water for their Paper Mills at Raniganj from the Damuda river owing to changes in its course, and that they contemplated boring for artesian water, Mr. H. Walker was deputed to examine and report on the possibilities of the project. He found that there was no prospect whatever of obtaining an artesian supply in the vicinity, and recommended the sinking of a number of bore-holes in the alluvium bordering the river, by which means a sufficient supply may be obtainable from a band of gravel underlying a bed of clay in the alluvium, which appears to have a considerable extension horizontally.

**Bombay: Borings in Gujarat.**

59. After many delays, due to the difficulty of finding a suitable site, the experimental boring in Gujarat with the Calyx drill, lent by the Geological

Survey Department, was at length started in the autumn of 1909, the site finally selected being near Sanand railway station, on the Ahmedabad-Wadhwan branch of the Bombay, Baroda and Central India Railway. A report on this boring has been furnished by the Engineer-in-charge, from which it appears that water was struck at a depth of about 300 feet from the surface, but not under artesian pressure. Pumping tests have proved that a discharge of about 5,000 gallons an hour is available, but the water is of inferior quality, and is not potable. In fact it is evident from the boring records that the water comes from a bed of sand in the alluvium, and is ordinary sub-soil water. It still remains to be proved, therefore, whether water under pressure can be obtained beneath the plains of Gujarat, but in places like Sanand the alluvium is probably too thick to be pierced by a boring of reasonable depth.

It is unfortunate that the site originally selected under the advice of this Department, to the north-east of Wadhwan, was found to be impracticable. Not only is the alluvium there probably much less deep than at Sanand, but there was a prospect of reaching the Tertiary strata which may underlie the alluvium, and which might have given a fair supply of artesian water.

**Burma: Artesian water at Pegu.**

60. At the request of the local Government, Mr. P. N. Datta visited the town of Pegu for the purpose of advising the Chief Engineer regarding the possibility of obtaining a supply of drinking water from artesian wells. Two sources had already been tapped by tube wells of 120 and 305 feet deep, respectively, at the Ice Factory in the town, and the existence of a water-bearing stratum at a depth of 580 feet had also been proved. Mr. Datta was of opinion, however, that the supply from the higher beds would not be sufficient for the town, as a considerable portion of it is taken by the Ice Factory, but if the water-bearing strata are continuous it should be possible to obtain a large supply from them, if several wells are sunk at such distances apart that they do not interfere with one another.

**Central India: Trial boring at Shamgarh.**

A trial boring for water at Shamgarh station on the Nagda-Muttra Railway proved unsuccessful, as the whole of the boring was in Deccan trap. It was thought that the trap-flow might be of small thickness, and that water might be found beneath it, but after boring to a depth of 217 feet the experiment was abandoned.

62. On his way to Upper Assam in November 1909, Mr. Hayden visited the tube wells at Chittagong which have been sunk by Messrs. Kilburn & Co. in accordance with the advice given by him after an inspection of the locality in 1906. In the first instance an experimental bore of $3\frac{3}{8}$ inches in diameter was put down to a depth of 700 feet. Three water-bearing bands were met with, one of 10 feet thick at 165 feet, the second of 40 feet thick at 215 feet, and the third of 92 feet thick at 335 feet from the surface, respectively. Below this no more water-bearing strata were found. The water from the band at 335 feet, that from the upper layers having been blocked off, rose to 8 feet below the ground level, and pumping tests showed that a constant yield of about 1,100 gallons an hour, capable of being largely increased with a more powerful pump, could be obtained from this band. It was then decided to sink two other tube wells of 6 inches diameter each, near the original boring, and these have now been drilled, but only one has been fitted with machinery for testing the yield. This is about 9,000 gallons per hour, and it is estimated that the two six-inch wells will give an ample supply for the town, the requirements being about 300,000 gallons a day. The water is derived from Tertiary sandstones which have their outcrop in a ridge of low hills lying to the south-west of the town and is therefore under artesian conditions, though the effective head, owing to the low elevation of the outcrop, is not sufficient to force the water above the orifice of the bore hole.

**Eastern Bengal and Assam: Chittagong.**

63. Since the year 1906, the Public Works Department has been engaged in putting down a boring for artesian water at Jorhat in Upper Assam. Last year this boring reached a depth of 365 feet, and samples of the strata passed through were sent to this Department for determination. From these it appears that the boring has not yet reached the base of the alluvium, and no indications of water under pressure have been met with.

**Jorhat.**

64. A boring was put down in the grounds of the Khalsa College at Amritsar in the hope of striking artesian water, but at a depth of 215 feet, operations were suspended through lack of funds. The boring records show that at this depth the alluvium had not been pierced, but the Principal of the College states that at 60 feet a practically unlimited

**Punjab: Amritsar.**

supply of water was met with, though not under pressure. The distance of Amritsar from the edge of the plains, about 50 miles, is probably too great to hold out much prospect of reaching the base of the alluvium at a reasonable depth from the surface.

**United Provinces: Bundelkhand.**

65. The Government of the United Provinces has asked our advice regarding the sinking of artesian wells in the portion of Bundelkhand not occupied by Native States; but the greater part of the area specified consists either of metamorphic rocks or alluvium, while the narrow strips of Vindhyan rocks in the Lalitpur district are so disposed that there is no prospect of obtaining artesian water from them. It would be useless, therefore, to spend money on deep borings in this area.

**Borings for subsoil water.**

66. The Department of Land Records and Agriculture in the same provinces has shown great activity in putting down shallow bore-holes as a preliminary to sinking percolation wells, with a very gratifying measure of success. During the official year ending in 1909, over 1,000 of these borings were made, and in certain cases samples of the beds passed through have been sent to this Department for determination. As a general rule, the borings are not over 100 feet in depth, being usually stopped at this point if water is not met with, and none of them appear to have been carried far enough to determine the thickness of the alluvium out in the plains.

## GEOLOGICAL SURVEYS.

### Aden.

**Capt. R. E. Lloyd, I.M.S.**

67. An interesting paper has been contributed to the *Records*, Vol. XXXVIII, Pt. 4, by Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, Marine Survey of India, giving the geological results of a tour made by him in 1906 through the little known country to the north of Aden. Mr. F. R. Mallet had made a short expedition through this country in 1870, but was only able to reach the foot hills and determine the presence of fossiliferous limestones there. Captain Lloyd was able to penetrate 40 miles into the hills, and ascended to Dala, which lies among hills of six or seven thousand feet in altitude. The rocks met with on the road were a sedimentary series of limestones and

sandstones and a more recent igneous series, covering a much wider area than the sedimentary rocks, and separated into :—

(1) Massive lavas :—these occur above the others and form plateaus and pinnacles which give a characteristic appearance to the landscape;
(2) Horizontally bedded lavas, consisting of alternating layers of compact black lava and amygdaloidal lava;
(3) Beds of volcanic ashes of brightly variegated colours, dipping at pronounced angles, usually less than 30°.

It is not quite certain from Captain Lloyd's description, whether the dip of these beds is original and due to the presence of a centre of volcanic activity in this neigbourhood, or whether it is due to subsequent tectonic disturbance. As Mr. Vredenburg points out, the sedimentary rocks are similarly inclined, and he thinks therefore that there may have been a long interval between the deposition of the ash beds and the eruption of the undisturbed massive lava, which may be of quaternary age, like the Aden volcano.

The sedimentary rocks are older than the igneous series, but the uppermost beds show traces, in the presence of beds of volcanic fragments, pebbles of lava, etc., of the setting in of volcanic conditions. The limestones are highly fossiliferous and have been shown by Mr. Tipper to be of Upper Jurassic age (*see* above p. 85).

The petrology of the rocks collected by Captain Lloyd has been worked out by Mr. Vredenburg (*see* above p. 85), and the results of his investigations, with those of Mr. Tipper on the palæontology are published in separate papers in the same part of the *Records*.

## Burma.

68. Part of the survey work in Burma is described above under the heading of *Petroleum*, wherever the areas dealt with have been mapped during the course of the search for new oil-fields. A considerable amount of mapping has also been carried out in other areas and a distinct advance made in the correlation and description of the Tertiary deposits.

**Thaton District, Lower Burma: Mr. P. N. Datta.**

69. In addition to the special enquiry into the suitability of the crystalline rocks of the Thatôn district for road metal, Mr. P. N. Datta made a geological survey of the western parts of the district.

The rocks met with were :—

Alluvium.

Laterite.

Sedimentary rocks :—Sandstones and shales, more or less metamorphosed in places.

Crystalline rocks :—(i) Volcanic (probably rhyolitic); (ii) Granite and (iii) Gneiss with mica and quartz schists.

**Section at Martaban.**

A good section of the sedimentary rocks was found in the new cuttings for the railway at Martaban Station. Here some of the shales are highly carbonaceous and contain plant remains, too fragmentary to admit of identification, and bivalves, with casts of what appear to be *Orbiculoidea* and the wings of insects. None of these is sufficiently well preserved or characteristic to enable the exact age of the beds to be determined, but there is no doubt that they belong to the 'Moulmein Group' of Dr. T. Oldham, and are probably of Carboniferous age.

The crystalline rocks are of ordinary types and call for no special remark, but Mr. Datta thinks that the granites and rhyolites, which were included by Mr. Theobald with the gneisses in his 'Martaban Group,' are really intrusive, and may be of post-Carboniferous age.

**Pegu beds, Yenangyaung.**

70. On his return from Kyaukphyu in February, Mr. Pascoe made an attempt to map the Pegu beds of Yenangyaung, but found that the conditions were such that no definite boundary lines could be drawn. At Yenangyaung the Pegu beds are of a shallow water type and extremely variable in thickness, so much so that it was found impossible to recognise the divisions made by Dr. Noetling, who separated the Pegu series into a lower or Prome stage, and an upper, or Yenangyaung stage. The question is of some importance, since if horizons of definite composition could be recognized in this enormously thick series of beds, it would render the mapping of the anticlines or domes beneath which petroleum is likely to be found, and the determination of faults, a much more simple matter than it is at present. Mr. Pascoe suggests that, instead of attempting to map the various groups of beds, which are constantly changing in composition, a better method would be to lay down each outcrop observed accurately on a large scale map, and deduce the

structure of the rocks from the series of strikes thus obtained. But the chief objection to this course would be the necessity of constructing a special map (on a scale of at least 8 inches to the mile) for each locality visited.

**The volcano of Popa: Mr. E. H. Pascoe.**

71. As a result of surveys carried on during the final months of two field seasons around the ancient volcano of Popa in the Myingyan district, more than half the area has been mapped. The northern part of the crater-wall is missing, and the rest is formed of breccia or agglomerate. There is a conspicuous parasitic cone on the west known as Taungkalat. A large part of the mountain is made of Irrawaddy sandstone, and a few small inliers of beds resembling the Pegu are observable in a few places. The oldest bed is an ashy tuff interbedded in the Irrawaddy sandstone. The lavas are mostly andesites, both hornblende and augite varieties being represented. An account of the volcano will be published as soon as the petrographical details of the rocks collected have been worked out.

**Country south of Mt. Popa: Mr. K. A. K. Hallowes.**

72. Mr. Hallowes was engaged in examining the country immediately south of Mt. Popa. The Kyaukpadaung Hills were found to be composed of altered silicified tuffs, with some interbedded altered rhyolites, associated with pumice and volcanic agglomerate. East of Leya altered tuff and rhyolite occur interstratified with Irrawaddy sandstones. The small hill of Taungnauk between Kyaukpadaung and Popa consists of altered silicified tuffs with some interbedded rhyolitic lava flows. The junction between the Pegu and Irrawaddy series south of Popa was found to be covered by an extensive sheet of hornblende-andesite. The crater of Mt. Popa itself, according to Mr. Hallowes, lies upon a fault. The hill known as Taungni was found to be composed of altered lavas and white flour-like tuffs, some of which have been highly silicified; it is probably an old tuff cone. Mr. Hallowes reports the discovery of tuffs interbedded in Pegu sandstones near Leya and elsewhere, indicating that volcanic activity in this area existed in pre-Pliocene times. East of the Kyaukpon hills is a large tract of Pegu rocks bent into more or less parallel anticlines striking about 30° W. of N. In these *Turritella acuticarinata* and *T. simplex* occur in great profusion. There are no good prospects of obtaining oil here.

**Western Prome: Mr. M. Stuart.**

73. The localities examined and mapped by Mr. Stuart during the season 1908-1909, were North-West Prome, South-West Thayetmyo, and Yenangyaung. The results of these surveys have already appeared in Vol. XXXVIII, Pts. 2 and 4, of the *Records*.

The mapping made it evident that Theobald's classification of the Pegu system was the most suitable one, *viz.* :—

4. Kama clays.
3. Upper Prome series.
2. Lower Prome series.
1. Sitsayan shales.

and that Noetling's later suggestion to incorporate the Kama clays and the Upper Prome series into one series, which he called the Yenangyaung stage, and the Lower Prome series and Sitsayan shales into another series, which he called the Prome stage, could not be entertained.

It also became evident that the old method of classifying the fresh-water deposits as the Irrawaddy system and the underlying marine beds as the Pegu system could no longer be adopted, but that the division between the two systems must be made at the horizon of the unconformity which exists some distance below the base of the fresh-water beds. This unconformity is scarcely visible in any individual section, but on mapping the junction of the two systems is seen to be of considerable importance and extent. This brings a series of marine beds into the base of the Irrawaddy system, which series is represented in the district mapped by the beds on which the town of Prome is situated. This series of marine beds is described by Theobald as overlying the Kama clays, but is incorporated by him with the Pegu system. The Kama clays are therefore the highest beds of the Pegu system seen in the district.

It was also ascertained that there is a distinct unconformity between the base of the Pegu system (Sitsayan shales) and the Bassein system. The age of the top-most beds of the Bassein system which are seen in the district are of Eocene age.

**Classification of Tertiary Strata.**

74. The succession in the district is therefore :—

Irrawaddy system . . . { Fresh-water series.
Marine series.

Unconformity.

| | | | |
|---|---|---|---|
| Pegu system . . . | 3. Kama clays. | | |
| | 2. Prome beds . | Upper series. | |
| | | Lower series. | |
| | 1. Sitsayan shales. | | |

Unconformity.

Bassein system.

**Oil horizon.**

75. Another point which was suggested by the detailed mapping of the district was that all the oil seepages in the district from the Pegu system come from the Kama clays, and that none occur in the system below this horizon. This observation is in direct conflict with Noetling's assertion that all the oil in the Pegu system comes from the Lower Prome series and Sitsayan shales (his Prome stage).

**Structure.**

76. The structure of the Padaukpin and Banbyin area proved to be an anticline in marine Irrawaddy beds with the underlying Kama clays exposed in the crest of the anticline. Owing to the unconformity between the two systems there is not any definite anticlinal structure in the Kama clays, which are here several thousand feet thick. The marine Irrawaddy beds have a lower angle of dip in an easterly direction than the underlying Kama clays, and where the latter again crop out near Aukmanein, some ten miles to the west, only 1,200 feet of them are seen.

In view of the discovery of this structure, the fossil evidence obtained from the oil-fields of Minbu, Yenangyaung, Singu, and Yenangyat was examined and was found to favour the view that in each case the structure was similar to that of the Padaukpin-Banbyin area, and that the Pegu beds exposed in the various oil-fields were an upper development of the Kama clays.

A separate investigation was carried out on the fossil-fish teeth obtained and their evidence generally supported the above view.

## Central India and Rajputana.

**Messrs. C. S. Middlemiss, H. C. Jones, A. M. Heron and N. D. Daru.**

77. During the working season, 1908-1909, the Central India and Rajputana party was composed as last year, but with the addition of Mr. Daru. In consequence, however, of the early completion of the linking up of the recent with the older mapped regions, the

portions under survey, after the first month or so, became disconnected: Messrs. Jones and Heron were drafted to Gwalior and Alwar respectively, for mineral investigations and checking of the old survey, whilst Mr. Daru continued the new survey in Partabgarh and Banswara. Mr. Middlemiss continued in charge of the party, but was only able to pay a short visit to the neighbourhood of Neemuch (North of Banswara) and to a portion of Alwar State.

**Mr. H. C. Jones: Indore and Jaora.**

78. The first two months of the season Mr. Jones spent in putting the finishing touches to his last year's mapping in the neighbourhood of Rampura in the Indore State and in parts of Jaora. This work, which connects our present survey with the old work of Messrs. Hacket and Kishen Singh, has already been summarised in some detail in last year's General Report (*Records*, Vol. XXXVIII, Pt. 1, p. 62). Nothing fresh of any importance was found in the area with the exception of a few small inliers of Delhi rocks among the Deccan Trap at Dhorwara (24° 13′; 75° 10′) and Diknio (24° 10′; 75° 5′), and some ancient workings for iron (magnetite and hematite of poor quality) in the Suket shales at Pardha (24° 32′; 75° 13′).

**Gwalior.**

79. The area next taken up by Mr. Jones was that of Gwalior State near Gwalior town, at those interesting localities where the Gwalior representatives of the Bijawar series are found lying unconformably above the Bundelkhand gneiss, and the Upper Vindhyans in turn unconformably above both.

The whole of this area had already been mapped on the one inch scale by Messrs. Hacket and Kishen Singh; whilst the former had also given a short but comprehensive account of its geological structure (*Records*, Vol. III, pp. 33-42, with map and further notes in *Records*, Vol. X, p. 84). The aim of Mr. Jones' visit was primarily to examine some mineral occurrences which the Gwalior Durbar was anxious to have an opinion about. Incidentally, however, a re-examination of the general geological structure of the country was undertaken, and typical specimens of all the rock series were gathered and described in more petrological detail than was previously possible. Mr. Jones' report is very full and is illustrated by numerous very clear photographs and a few local sections. Much of it, however, is a repetition of observations already made by

Hacket, expanded by further detail, and enlarged by more illustrative descriptions of local occurrences. The general stratigraphy of the area remains unchallenged. No better examples of the supposed corals (as recognised by Dr. Stoliczka) from the limestone bands of the Morar shales (see *Records*, Vol. III, p. 35) were obtained, and Mr. Jones has been unable so far to improve upon the successional arrangement of the series of limestones, traps, felsitic rocks, shales, jasper, hornstone and clay bands belonging to the Morar series, in expansion of Hacket's section given at p. 36 (*loc. cit.*). They still appear very vaguely outlined as lying generally above the Par sandstone at uncertain positions, whilst the genetic relations of many of these remarkable petrological types has not been further enquired into (compare rocks of the same age and general composition in the Son valley; *Memoirs*, Vol. XXXI, Pt. 1, pp. 58-92). The following is a brief outline of Mr. Jones' results as obtained in his examination of sheets 365, 366, 383, 399, 400, and 401 of the Central India and Rajputana topographical survey, between latitudes 25° 45′ and 26° 15′ and longitudes 78° 0′ and 78° 45′.

**Bundelkhand gneiss and quartz reefs.**

80. Typical Bundelkhand gneiss with pegmatites and quartz reefs, agreeing in every way with the descriptions of Mallet (unpublished reports summarised in the *Manual*, 2nd Edn., p. 27), occupy the low ground in the south-east of the area, and Mr. Jones has given a number of particular descriptions from special localities, accompanied by microscopical determinations. All appear to be varieties due to local concentration, or particular mineral segregation, of one Archæan mass that cannot be further subdivided.

**Galena and Copper Ores.**

81. It is in these rocks that trenches have been opened for galena at Ragonathpur (26° 4′; 78° 20′) at Bhilowa (26° 3′; 78° 20′) and kaolin quarries at Antri (26° 3′; 78° 17′). Specks of galena and some pyromorphite were found in the first, but nothing at Bhilowa. Traces of galena, malachite and azurite were also found 2½ miles west of Karhia (25° 54′; 78° 4′).

Scarcely any metallic minerals were found in the quartz reefs penetrating the gneiss. Small specks of copper pyrites, covellite and malachite are mentioned as present, but no gold. Assays of 4 of these veins were made in the Geological Survey laboratory by Mr. Blyth without any trace of gold or silver being obtained. The

pure white variety of quartz from the reefs is used for the manufacture of glass at the Gwalior (Morar) works.

**Trap dykes.**

82. The trap dykes of the area, previously described by Mallet (*loc. cit.*) are identified by Mr. Jones as ophitic dolerites, consisting of pale brown augite, plagioclase felspar (labradorite), magnetite, and ilmenite frequently altered to leucoxene. Altered varieties occur containing saussuritised felspar, hornblende, epidote, quartz, chlorite and hematite.

**Bijawar Rocks and Upper Vindhyans.**

83. A large number of notes on the Bijawar rocks of the area (Par sandstones and Morar group of shales) have been put together by Mr. Jones in amplification of Hacket's original description (*Records*, Vol. III, pp. 33-42). They constitute a set of isolated petrographical descriptions of specimens and sections from many localities, but as already remarked, their mutual relations and mode of origin have not as yet been further elucidated.

**Interbedded traps.**

84. The interbedded traps associated with the shales compose five main spreads, and have been determined as labradorite-augite-magnetite rocks.

**Mr. A. M. Heron: Alwar State.**

85. Mr. Heron, in his new survey of Alwar State, has contributed a very carefully coloured map and detailed report, illustrated with sections and an admirable array of photographs. The area treated of is chiefly in Alwar, with portions of Jaipur and Bharatpur States, as shown in sheets 286, 287, 288, 314, 315, 316, 339 and 340 of the Central India and Rajputana topographical survey.

**General Results.**

86. His results comprise a return to the original view of Hacket (*Records*, Vol. X, Pt. 2, p. 85) as regards the rock succession, a matter which requires a few words of explanation. In the above cited reference, Hacket, after surveying the area in detail, arranged the formations as below :—

| | | | |
|---|---|---|---|
| Arvalis | Mandan | group | of slates, schists and quartzites; |
| | Ajabgarh | ,, | of slates, quartzites, hornstone-breccia and limestone; |
| | Alwar | ,, | of quartzites, conglomerates, schists and bedded trap; |
| | Raialo | ,, | of limestone and quartzite; |

and the small-scale map, illustrating that published report is coloured according to this scheme. Later, however, in consequence of

work in other parts of Rajputana to the west, he formally abandoned this view (*Records*, Vol. XIV, Pt. 4, p. 281) and wrote:—

"In my description of a portion of this area, the Alwar hills, in a previous paper, I placed the Ajabgarh and Mandan groups at the top of the Arvali series above the Alwar quartzites. Upon further examination of the series in the country to the west, where the sections are less broken, I found that this was not the true interpretation of the section, but that both these groups were below the quartzites, in fact, representatives of the Raialo group. I was led into this error by the high dip of the rocks and by taking inversion for the normal sequence.

I also then included the Alwar quartzites with the Arvali series, but as in the western area the quartzites are found to constantly overlap the lower rocks; as also several cases of unconformity have been noticed it is necessary to separate these two series. As the quartzites extend up to Delhi and form the ridge there, I now propose to call the qartzites and their associates in the Mandsaur hills and elsewhere the Delhi series, retaining the name of the Alwar quartzites for the lower member of the series."

A small-scale map illustrating the above paper is also coloured according to the new view; whilst, what is of even more importance, the signed fair copies of the large-scale, 1″ = 1 mile, maps handed in by Mr. Hacket in 1882, and stored now in the map cases of the department were also coloured according to this later view and indexed thus:—

Delhi series (= Alwar quartzites).
Arvali series with limestone, hornstone breccia,
and trap (= Ajabgarh series).

It sholud be noticed that this change of view of Hacket was made without his resurveying the Alwar area, and without his supporting it by detailed sections. His paper in Vol. XIV of the *Records* being the last published account that Hacket wrote.

**Hornstone-breccia and thrust-plane.**

87. Mr. Middlemiss, on visiting the area for a few weeks in Mr. Heron's company during the latter's survey, was particularly struck by the peculiar appearance and lie of the hornstone breccia, which both he and Mr. Heron agreed in viewing as a fault-breccia due to an *in situ* smashing and tearing asunder of the beds at various horizons near those of the Kushalgarh limestone and the Ajabgarh shales. Mr. Middlemiss, believing it to be the record of a great thrust-plane, suggested to Mr. Heron that it might possibly account for the two opposite interpretations of the sequence held by Mr. Hacket at different times. Mr. Heron, however, in his report,

whilst accepting the theory of it as a nearly horizontal plane of movement, does not accept this suggestion as accounting for the sequence observed, which he simply describes in full detail on the basis of the original (but since superseded) description of Hacket as given in Vol. X. of the *Records.*

Although the full petrographical descriptions of Mr. Heron are very carefully worked out, and are a distinct advance on anything hitherto attempted, it is to be hoped that further work in adjacent areas will enable Mr. Heron to clear up this question categorically.

**Mr. N. D. Daru: Partabgarh and Banswara.**

88. Mr. Daru broke new ground in Banswara, continuing in a north and westerly direction the survey of that state already begun by Mr. Heron during the previous field season. In preparation for this he, in the first instance, spent a short time in the neighbouring state of Partabgarh, accompanying Mr. Heron in a study of the rock groups there displayed along the junction of the old work and the new.

**Area surveyed.**

89. Mr. Daru was able to map geologically a considerable area within sheets 175, 176, 208 and 209 of the Central India and Rajputana topographical survey, the last two of which (begun by Mr. Heron) he has now completed.

In carrying out this he followed the delineation scheme of his predecessors as closely as possible. The outliers of Deccan Trap, which lie flatly in the usual, absolutely unconformable way above the older rocks, were continued into the newly explored ground, where they were found to occupy the higher hills and ranges. As regards the older systems, he was able to distinguish and separate from a general ground work of presumably Archæan gneisses and other crystalline rocks, a set of presumably much younger, metamorphosed sedimentary rocks, consisting of limestones, shales, slates or phyllites, garnet-quartz-biotite schists, boulder beds and schistose conglomerates. These were found to be all highly inclined or vertical as to their dip, either forming comparatively large spreads or narrow and frequently interrupted strips with a general N. 30° W.—S. 30° E. alignment.

**Difficulties of interpretation.**

90. In spite of the wide areas of these rocks exposed in certain parts of Banswara, both Mr. Heron and Mr. Daru found difficulty in interpreting the depositional order of the various sediments which

compose them. Their outcrops are certainly not wanting in continuity and parallelism over considerable tracts; but the chief difficulty seems to be their obscure junctions with the Archæan ground-work, and their steep dips; which latter, even where they occasionally give rise to anticlinal and synclinal flexures, nevertheless cause the younger series to appear as a whole more like parallel packets of strata thrust on edge amongst the Archæans than like outliers resting upon the same. Mr. Daru is disposed to accept a descending order agreeing with that given in the preceding paragraph, with the exception that the limestone bands appear at varying horizons.

**Equivalents of Hacket's Aravallis.**

91. Notwithstanding this, Messrs. Heron and Daru's work taken together comprises a detailed descriptive account and large-scale map covering their joint area which now become of value in discussing questions of correlation. The younger metamorphic series as a whole, and certainly as regards its larger spreads, must now be regarded as identical with the great group which has been classified by Hacket as Aravallis, and mapped by him in the sheets a little way to the north of the area now dealt with. It would also seem to be likely that the interrupted bands of crystalline limestone, quartzite, limonite-quartz rock, grünerite rock, etc., which appear in very narrow outcrops among the wide area of mixed gneisses, and which were last year temporarily included with the mixed gneisses, should also be considered as long extended outcrops connected with the younger series rather than with the older Archæan complex—or as outcrops owing their narrow interrupted state to the circumstance that they are the remnants of almost obliterated troughs of compressed folds. This last explanation at all events seems to be the only one capable of accounting for the very elongated strip of the Masania conglomerate (23° 57′; 74° 34′) which continues for many miles with a very narrow outcrop as an isolated band among the gneisses.

**Conglomerates and Boulder beds.**

92. The conglomerate mentioned above is composed of flattened lenses of quartz held together by an argillaceous, chloritic or sericitic cement, and roughly resembling augen-structure; but another much coarser conglomerate or boulder bed, which Mr. Daru now thinks distinct from the former, is of considerable interest. It occurs prominently at Loaria (23° 46′; 74° 10′) and resembles that from Kusalgarh described by Mr. Heron, having a matrix of biotite schist,

and contained boulders ranging up to the size of three times a man's head. These are subangular in shape, and consist of granite, gneiss, syenite and fragments of quartz, of felspar and of biotite rock. This remarkable bed is in direct connection with the schists and phyllites of one of the larger spreads of the younger metamorphic series.

**Suggested resemblance to the Dharwars.**

93. A boulder bed of the above nature, so agressively significant of all that can be implied by a great unconformity, is nevertheless at variance with the peculiar position of the whole series, smothered as it appears to be by the surrounding gneissic system, and also at variance with other evidence of intrusive action both of quartz veins and granite among many members of the series. We are herein reminded of the similar paradoxical relations subsisting between the Dharwars and massive gneisses of South India, a resemblance which may even not be without value as an index of age.

In view of the position suggested by Mr. Daru for the conglomerate and boulder bed among the younger metamorphic Aravallis, it is difficult to correlate it with the somewhat similar boulder bed near Udaipur to the north. The latter is said to occur doubtfully at the base of the Alwar quartzite and between it and the older schists. (C. A. Hacket, MS. Report, 1886, quoted in the *Manual*, 2nd Edn., p. 68.)

**Doubtful rocks.**

94. Both Mr. Heron and Mr. Daru have, in addition to the above, recorded some compact quartzites and schists which they cannot definitely assign to the younger (Aravalli) series; whilst at the same time they consider them as unlikely to belong to the still newer Delhi series of Hacket. In these cases, as in all those involving narrow strips of rock types isolated by want of exposures or by alluvium, the coincidence of strike that obtains throughout all the rock complexes below the Deccan Trap, renders the sorting of every known outcrop exceedingly difficult.

**Archæan complex.**

95. No attempt was made to limit by definite boundaries and colours on the map the various members of the Archæan system among themselves. In this matter Messrs. Heron and Daru have both been compelled to follow the only feasible plan of indicating by one or two signs superposed on one uniform wash of colour such marked lithological types

as massive acid and basic intrusions, wherever such could be distinguished as exercising a predominating effect in the field. Thus the mixed gneisses are left in possession of the greater part of the area coloured Archæan, with here and there patches of granite, syenite, aplite, pegmatite and basic dyke rocks. This, though a superficial method, and one giving no clue to the genetic relationships of the rock masses to one another, is nevertheless a slight advance on the work of the older survey in neighbouring parts; but it would be premature at present to attempt any closer descriptive summary of results. This rock group may undoubtedly, as a whole, be correlated with the "gneiss" of Hacket in the area of the Aravalli Range to the north.

## Punjab.

**Dr. G. E. Pilgrim: Upper Tertiary Fresh-water strata.**

96. In continuation of his survey of the ossiferous deposits of India, Dr. G. E. Pilgrim visited that portion of the Punjab, lying between the Jhelum and the Indus, known as the Potwar, the Salt Range and the Murree Hills. Sub-Assistant M. Vinayak Rao was employed in collecting from the same district under Dr. Pilgrim's direction.

As the result of his investigations, Dr. Pilgrim has been able to arrive at certain definite and important conclusions regarding the divisions of the Tertiary fresh-water strata of the Punjab, and their correlation with the Siwalik formation in other parts of India. A full summary of these conclusions with a revised classification of the Upper Tertiaries of India will appear in this volume of the *Records*.

**Kuldana series of Fatehjang.**

97. In the first place Dr. Pilgrim shows that the nummulites associated with the mammalian fauna of Fatehjang, near Rawalpindi, which led Lydekker to refer these beds to the eocene (Khirthar) period are not *in situ*, and that great unconformity really exists between these beds and the Khirthars. The presence of *Anthracotherium bugtiense*, *Brachyodus africanus*, and other Upper Nari forms, clearly denotes the age of these beds, which are identified with the Kuldana series of Middlemiss, and pass upwards into the Murree sandstones. These latter beds thin out rapidly towards the south and are not represented in the Salt Range, where the Kuldana beds

are followed by a series of beds correlated with the lower Siwaliks of Sind and the Bugti Hills.

**Middle Siwaliks of the Potwar.**

98. One of the most important discoveries made by Dr. Pilgrim is the fact that the collections made by Mr. Theobald in the Potwar, from beds supposed to be on the same horizon as those mentioned above, really belong to a horizon some 5,000 to 8,000 feet higher in the series. This fauna, to which Dr. Pilgrim restricts the term Middle Siwalik, is quite distinct from the lower one, the most striking features being the absence of *Dinotherium* and the abundance of *Hipparion*, Giraffoids and the large antelopes. Furthermore, Dr. Pilgrim has proved the passage of these Middle Siwaliks upwards into beds containing a fauna identical with that of the Siwalik hills in the typical area. These latter beds had been traced by Medlicott and Theobald in practical stratigraphic continuity through Jamu and Kangra as far as the Pabbi Hills on the east side of the Jhelum, so that it now becomes possible to correlate the Siwaliks of the Siwalik Hills with the Upper Tertiaries of Western India.

**Siwalik Hills.**

99. Dr. Pilgrim also paid a visit to the Siwalik Hills in order to investigate a supposed bone deposit. This turned out to be merely a deposit of calcareous tufa; but he was able to revisit several of the old localities, which appear to have been worked out by former collectors, and discovered the important fact that most if not all of these localities are near the top of the series. The whole series of beds form a perfectly conformable sequence, and the occurrence of *Dinotherium* and species identical with those of the lower Siwaliks of the Salt Range shows that lower horizons are also represented. This is the so-called Nahan stage. With the exception of these lowest beds, the rest of the series, including both Mr. Middlemiss 'Siwalik conglomerate' and 'sand-rock' stages, corresponds both in thickness and lithological character with the Upper Siwaliks of the Pabbi Hills. The conclusion is therefore drawn that the middle Siwalik stage in the Siwalik Hills was characterised by a remarkably slow deposition, only a few hundred feet representing the 6,000 feet or so of the fossiliferous Middle Siwaliks of the Salt Range.

No reason whatever has been seen to doubt the propriety of separating the Dagshai and Kasauli series from the Nahans, or the identity of the two former with the Murree series of the Punjab.

## Kashmir.

**Mr. C. S. Middlemiss: District S. E. of Srinagar.**

100. During the summer of 1909, Mr. Middlemiss revisited Kashmir, and added considerably to the discoveries made the previous year, which have been described in Vol. XXXVII, Pt. 4, of the *Records* and in the General Report for the year, Vol. XXXVIII, Pt. 1, p. 69. A full account of these later observations will appear in the current volume of the *Records*.

The area examined is a compact one, about 36 miles long by 16 miles broad, lying to the south-east of Srinagar, embracing the area in the Vihi district examined in detail last year and sections along the Patarkul, Traal, Lidar, Arpat and Naubug valleys, which, with a north-east—south-west trend, join the Jhelum valley above Srinagar.

In his progress through this area, Mr. Middlemiss soon found that the old interpretation of the geological series as formulated by Lydekker (*Memoirs*, Vol. XXII) needed much revision as a sequel to the more recent detailed surveys, which since Lydekker's time have been made of the Tibetan watershed of Garhwal and Kumaun, and in Spiti. A new map was therefore produced of this very typical area, and a re-grouping of the fossiliferous marine sedimentary series from Silurian to Upper Trias was instituted.

**Geological sequence.**

101. A large and characteristic collection of fossils was made from many of the horizons as given in the table of formations below (arranged in descending order) :—

| | |
|---|---|
| (12) U. TRIAS . . | (not differentiated into sub-zones). |
| (11) MUSCHELKALK . | *Ptychites* horizon.<br>*Gymnites* do.<br>Nodular limestone. |
| (10) L. TRIAS . . | *Meekoceras* horizon.<br>*Ophiceras* do. |
| (9) ZEWAN OR CARBONIFEROUS . | *Spirifer Rajah* and *Marginifera* beds.<br>*Protoretepora* limestone and shales. |
| (8) L. GONDWANAS . | *Glossopteris* horizon (Karharbari ?)<br>*Gangamopteris* do. (Talchir ?) |
| (7) VOLCANIC FLOWS. | |
| (6) AGGLOMERATIC SLATE SERIES. | |
| (5) M. CARBONIFEROUS (?) *Fenestella* series. | |

| | |
|---|---|
| (4) L. CARBONIFEROUS. | *Syringothyris* limestone series. |
| (3) MUTH QUARTZITE. | |
| (2) U. SILURIAN. | *Orthis* shales. |
| (1) L. SILURIAN AND CAMBRIAN ? | (traces of fossils only). |

Of these, the horizons of the Upper Silurian and Muschelkalk, for the first time during this visit, were identified by beds containing abundant faunas and arranged in regular sequence with the other formations round an elongated anticlinal axis which pitches to the North-West in the neighbourhood of the Lidar valley.

**Age of the Panjal Traps.**

102. Incidentally it will be observed that the removal of the so-called Panjal traps and conglomerates of Lydekker (Nos. 7 and 6 of the table) from a low position among the (?) Silurians of that author to a much higher level, immediately below the Permo-Carboniferous and Lower Gondwanas, has been found to be necessary, as was tentatively announced in the account of the previous season's work on the Lidar valley sequence (*op. cit.*, Vol. XXXVII, p. 322).

# THE MINERAL PRODUCTION OF INDIA DURING 1909. BY

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## CONTENTS:



## I.—INTRODUCTION.

THE present summary of the returns of mineral production in India during 1909 covers the first year of a new quinquennial period, the returns for the five years 1904—1908 having been dealt with by Sir T. H. Holland and Dr. L. L. Fermor in the Quinquennial Review published as Vol. XXXIX of these *Records*. The arrangement adopted in the annual statements issued previous to 1908 is therefore reverted to, that is to say, the minerals are grouped in two divisions, *viz.* :—

*Group I.*—Those for which approximately full returns are obtainable; and

*Group II.*—Those for which returns are admittedly incomplete or only approximately estimated.

One mineral, namely silver-lead ore, has been removed from Group II to Group I, for since the opening up of the silver-lead mines of Bawdwin in the Northern Shan States, more reliable figures than before are available in respect to the production of this mineral.

**Total value of production.**

A summary of the total values of minerals produced in 1908 and 1909 is given in Table 1. There have again been more or less pronounced increases in the value of gold, petroleum, saltpetre and jadestone; while manganese-ore, mica, ruby, iron-ore and diamonds, the production of which had decreased in 1908, now show signs of recovery; but there was a decided drop in the value of coal, as anticipated by Sir T. Holland in his last year's statement, due to the depression in trade that followed the extraordinary activity of the years 1906—1908. While the sharp drop in the value of magnesite, from £2,009 in 1908 to £196 in 1909, again demonstrates how precarious is the demand for such minerals and how quickly they respond to changes in the European market. Salt, graphite, chromite, tin-ore, and amber have also suffered a decrease.

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1908 and 1909.*

| MINERALS. | 1908. | 1909. |
|---|---|---|
| | £ | £ |
| Gold | 2,177,847 | 2,204,866 |
| Coal | 3,356,209 | 2,779,865 |
| Manganese-ore (*a*) * | 498,269 | 508,483 |
| Petroleum | 702,009 | 910,172 |
| Salt (*b*) | 522,794 | 453,630 |
| Saltpetre (*a*) | 292,758 | 296,838 |
| Mica (*a*) | 139,513 | 156,199 |
| Ruby, Sapphire and Spinel | 47,954 | 58,649 |
| Jadestone (*a*) | 74,402 | 84,450 |
| Graphite | 14,365 | 12,529 |
| Iron-ore (*c*) | 15,149 | 16,563 |
| Tin-ore | 11,015 | 9,645 |
| Chromite | 6,338 | 5,767† |
| Diamonds | 940 | 1,089 |
| Magnesite (*d*) | 2,009 | 196 |
| Amber | 364 | 287 |
| TOTAL | 7,861,935 | 7,499,228 |

(*a*) Export values. (*b*) Prices without duty. (*c*) Estimated values for provinces other than Bengal. (*d*) Estimated values.
* Exclusive of exports from Murmugao.
† Exclusive of the value of the output from Mysore.

The net result is that for the first time since these statistics have been published in the *Records*, there has been a drop in the

total value of mineral production, from £7,861,935 in 1908 to £7,499,228 in 1909, a decrease of 4·6 per cent. It must be observed, however, that this fall in value does not denote any serious diminution in the activity displayed in exploiting the mineral resources of the country, for it was the over-speculation of the previous years that caused the abnormal production of coal, the mineral mainly responsible for the decrease, in 1908, leaving huge stocks to be disposed of in the next year when, as a natural result, the average price per ton fell from Rs. 3-15 to Rs. 3-8.

**Mineral Concessions granted.**

There was a considerable drop in the total number of mineral concessions granted from 816 in 1908 to 693 during the year under review; but there was a very great increase in the number of mining leases, the figures being 71 and 156, respectively. The satisfactory aspect of this increase, however, which might be taken to mean that the activity shown in prospecting operations throughout the whole of India during previous years is resulting in a permanent expansion of the mining industry, is somewhat discounted on analysing the figures. For no less than 95 of these leases have been granted in a single province, Baluchistan, and 76 of these are for chromite alone, while it seems hardly possible that with the limited demand that exists for this mineral, every one of these ventures should become a financial success. If we omit the figures for Baluchistan the number of leases granted in other provinces indicates a no more than normal development of the industry.

## II.—MINERALS OF GROUP I.

| | | | |
|---|---|---|---|
| Chromite . . | Graphite . . | Manganese-ore . | Salt. |
| Coal . . | Iron-ore . . | Mica . . | Saltpetre. |
| Diamonds . . | Jadeite . . | Petroleum . . | Silver-lead ore |
| Gold . . | Magnesite . . | Ruby, Sapphire and Spinel. | Tin-ore. |

## Chromite.

The output of chromite in Mysore during 1909 amount to 4,925 tons, as against 610 tons in 1908. The value has not been reported. In Baluchistan the output for 1909 amounted to 4,325 tons, valued at £5,767, as against 4,135 tons, valued at £5,513, in 1908. The average production for the five preceding years was 4,418 tons.

## Coal.

**Total production.**

For the first time since the year 1882 a decrease in the total amount of coal raised in India has to be recorded, the production having fallen from 12,769,635 tons in 1908 to 11,870,064 tons in 1909. But, as has already been pointed out, the decrease is due to causes quite extraneous to the coal mining industry, if we keep in view its relation to the economic development of the country. The resources of India with regard to coal, and the effects that will be ultimately produced on her progress in such forms of industry as depend upon the possession of those resources, have not been in the slightest degree diminished or vitiated by the interference of people whose only object is speculation, and it is probable that, with the experience gained during the last three years, the industry will be allowed to develop along normal lines.

The deficiency in output is accounted for by the coal-fields of Bengal alone, where it amounted to 899,100 tons, the fluctuations in other provinces of India almost exactly balancing each other.

**Value and average price.**

The value of the coal produced fell from £3,356,209 in 1908 to £2,779,865 in 1909 as a natural consequence of the over production of the former year. This is shown by the fact that whereas the total value has been reduced by 17 per cent., the decrease in production was only 7 per cent. The average price of the mineral fell from Rs. 3-15 per ton in 1908 to Rs. 3-8 per ton in 1909, but it varies considerably in different provinces, as shown in Table 2.

TABLE 2.—*Average Price (per ton) of Coal extracted from the Mines in each Province during the year 1909.*

| Province. | Average price per ton. Rs. | a. | p. |
|---|---|---|---|
| Assam | 4 | 12 | 0 |
| Bengal | 3 | 4 | 0 |
| Rajputana (Bikaner) | 3 | 6 | 0 |
| Central India | 3 | 9 | 0 |
| Punjab | 7 | 15 | 0 |
| Baluchistan | 10 | 12 | 0 |
| Central Provinces | 4 | 9 | 0 |
| Nizam's Territory | 6 | 4 | 0 |
| Others | 5 | 0 | 0 |

**Provincial production.**

The production of coal in the various provinces of India is shown in Table 3. It will be noticed that Bengal shows the largest reduction, the fluctuations in the other provinces being unimportant, and practically balancing each other.

TABLE 3.—*Provincial Production of Coal during the years 1908 and 1909.*

| PROVINCE. | 1908. | 1909. | Increase. | Decrease. |
|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. |
| Baluchistan . . . . . | 45,212 | 52,449 | 7,237 | .. |
| Bengal . . . . . | 11,559,911 | 10,660,811 | .. | 899,100 |
| Central India . . . . | 155,107 | 121,496 | .. | 33,611 |
| Central Provinces . . . . | 213,789 | 238,100 | 24,311 | .. |
| Eastern Bengal and Assam . . | 275,224 | 305,563 | 30,339 | .. |
| Hyderabad . . . . . | 444,211 | 442,892 | .. | 1,319 |
| North West Frontier Province . | 90 | 96 | 6 | .. |
| Punjab . . . . . | 54,794 | 37,208 | .. | 17,586 |
| Rajputana (Bikanir) . . | 21,297 | 11,449 | .. | 9,848 |
| TOTAL . | 12,769,635 | 11,870,064 | 61,893 | 961,464 |

**Geological classification:— Gondwana coal-fields.**

Tables 4, 5 and 6 classify the production according to the geological formation worked. In spite of the reduced output in Bengal, where all the coal raised comes from the Gondwana system, the proportion of this coal to that from the Tertiary formations remains nearly the same as before, namely 96·57 to 3·43, in place of 96·9 to 3·1 per cent. All the coal-fields of Bengal participated in the reduction, except the little Rajmahal field, which increased its output from 333 to 1,900 tons, but the Jherria field still heads the list, with an output of 5,832,672 tons, and accounts for practically half of the Indian total. A new field, the Ramgarh-Bokaro, in Chota Nagpur, one of the outlying fields surveyed many years ago by the late Mr. T. W. H. Hughes, is now being opened up and figures for the first time in these returns. In the Central Provinces the recently opened Bellarpur field has increased its output by 88 per cent., and there has also been an increase of nearly 26 per cent. at Mohpani, but the Pench Valley field shows some falling off.

TABLE 4.—*Origin of Indian Coal raised during 1908 and 1909.*

| —·— | Average of preceding five years. | 1908. | 1909. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| From Gondwana coal-fields . . . . | 9,648,707 | 12,373,018 | 11,463,299 |
| From Tertiary coal-fields . . . . | 418,226 | 396,617 | 406,765 |
| TOTAL . | .... | 12,769,635 | 11,870,064 |

TABLE 5.—*Output of Gondwana Coal-fields for the years 1908 and 1909.*

| COAL-FIELDS. | 1908. | | 1909. | |
|---|---|---|---|---|
| | Tons. | Per cent. of Indian total. | Tons. | Per cent. of Indian total. |
| *Bengal*— | | | | |
| Daltonganj . . . . | 96,391 | ·76 | 84,290 | ·71 |
| Giridih . . . . . | 782,763 | 6·13 | 704,593 | 5·93 |
| Jherria . . . . . | 6,458,643 | 50·58 | 5,832,672 | 49·14 |
| Rajmahal . . . . | 333 | .. | 1,900 | ·04 |
| Ramgarh-Bokaro . . | .. | .. | 2,544 | |
| Raniganj . . . . | 4,221,781 | 33·06 | 4,034,812 | 33·99 |
| *Central India*— | | | | |
| Umaria . . . . | 155,107 | 1·22 | 121,496 | 1·02 |
| *Central Provinces*— | | | | |
| Bellarpur . . . . | 45,299 | ·35 | 85,237 | ·72 |
| Pench Valley . . . . | 120,249 | ·94 | 92,196 | ·77 |
| Mohpani . . . . | 48,241 | ·38 | 60,667 | ·51 |
| *Hyderabad*— | | | | |
| Singareni . . . . | 444,211 | 3·48 | 442,892 | 3·74 |
| TOTAL . | 12,373,018 | 96·90 | 11,463,299 | 96·57 |

**Tertiary coal-fields.**

The Tertiary coal-fields call for no special remark except in the case of the Salt Range collieries, where there has been a decided falling off, especially in the Shahpur field. This is only what might have been expected in view of the unscientific methods by which the deposits are worked. So long as mere grubbing at the outcrop is practised, each hole being abandoned, either as soon as the coal catches fire,

which it is very apt to do spontaneously in shallow workings on account of the exposure to the atmosphere of the pyrites associated with it, or from other difficulties, there is no prospect of the industry being placed on a sound footing. The seam, which is very variable in thickness, has so far only been worked along the southern scarp of the Range, and no attempt has been made to ascertain whether it extends beneath the limestone of the plateau to the north of the scarp, where it is quite possible that large stores of coal are concealed. Its existence can only be proved by boring, and a scheme is now being discussed for a thorough exploration of the plateau by this means.

The fluctuations in the output of these Tertiary coal-fields is due partly to the generally inferior character of the coal as compared with Gondwana coal, except perhaps in the case of Assam, and partly to the fact that it is mainly raised for local purposes only, and has no large or well established market. This is especially the case in Bikanir, where much difficulty has been experienced in utilising the coal on the railways.

TABLE 6.—*Output of Tertiary Coal-fields for the years 1908 and 1909.*

| COAL-FIELDS. | 1908. | | 1909. | |
|---|---|---|---|---|
| | Tons. | Per cent. of Indian total. | Tons. | Per cent. of Indian total. |
| *Baluchistan*— | | | | |
| Khost . . . . . | 31,547 | ·25 | 40,237 | ·34 |
| Sor Range, Mach, etc. . | 13,665 | ·10 | 12,212 | ·10 |
| *Eastern Bengal and Assam*— | | | | |
| Makum . . . | 275,224 | 2·15 | 305,563 | 2·57 |
| *North West Frontier Province*— | | | | |
| Hazara . . . . . | 90 | ·43 | 96 | ·32 |
| *Punjab (Salt Range)*— | | | | |
| Jhelum District . . . | 41,407 | | 34,135 | |
| Mianwali . . . . | 702 | | 45 | |
| Shahpur . . . . | 12,685 | | 3,028 | |
| *Rajputana*— | | | | |
| Bikanir . . . . | 21,297 | ·17 | 11,449 | ·10 |
| TOTAL . | 396,617 | 3·10 | 406,765 | 3·43 |

**Exports and Imports.**

There was a slight further drop in the exports of Indian coal and coke during the period under review, from 659,594 tons, valued at £382,369, in 1908, to 563,940 tons, valued at £338,395, in 1909. The destination of this coal is shown in Table 7.

TABLE 7.—*Exports of Indian Coal.*

| | 1908. | 1909. |
|---|---|---|
| | Tons. | Tons. |
| Aden . . . | 11,224 | 3,460 |
| Ceylon . . . | 424,060 | 312,507 |
| Straits Settlements | 108,608 | 128,371 |
| Sumatra . . | 97,484 | 79,394 |
| East Africa . . | 2,658 | .. |
| Other countries . | 13,440 | 38,822 |
| TOTAL | **657,474** | **562,554** |
| Coke . . . | 2,120 | 1,386 |
| TOTAL of Coal and Coke | **659,594** | **563,940** |

The imports of coal and coke during the same period are shown in Table 8. These do not seem to have been affected by the over-production of previous years, but show a distinct rise except in the case of Australia, where the output was restricted owing to labour troubles.

**Consumption of coal.**

The total consumption of coal, coke and patent fuel in India amounted to 11,796,545 tons in 1909 as against 12,515,644 tons in 1908, but the ratio of the quantity of coal consumed with respect to the total Indian production rose from 94·8 to 95·3 per cent. The quantity of coal

TABLE 8.—*Imports of Coal, Coke and Patent Fuel during 1908 and 1909.*

| — | 1908. | 1909. |
|---|---|---|
| | Tons. | Tons. |
| From Australia (including New Zealand) | 129,699 | 54,792 |
| Japan | 2,960 | 11,413 |
| Natal | 71,831 | 91,907 |
| United Kingdom | 156,233 | 290,719 |
| Other countries | 7,350 | 21,057 |
| TOTAL | 368,073 | 469,888 |
| Coke | 17,241 | 14,077 |
| Patent fuel | 9 | 6,456 |
| Government Stores | 6,198 | 29,567 |
| TOTAL | 391,521 | 519,988 |

consumed on Indian railways rose from 3,683,727 tons in 1908 to 3,765,314 tons in 1909, of which 3,689,093 tons were raised in India. This represents 31 per cent. of the total production of Indian coal as against 28·2 per cent. in 1908. The percentage of foreign coal consumed on the railways remained the same, *viz.*, about 2 per cent.

**Labour.**

The statistics of labour in the Indian coal-fields were fully discussed in the Quinquennial Review for 1904—1908, and a brief notice therefore is all that is necessary here. The output of coal per person employed showed little change, being 99·3 tons for the total number, and 153 tons for each person employed below ground. Table 9 gives the number of persons employed in coal mining in each province, the death-rate and the output of coal for each person killed by accident. There was a decided drop in the number of accidents from 178 in 1908 to 128 in 1909, and a reduction from 1·37 to 1·07, in the rate per thousand persons employed.

TABLE 9.—*Average number of Persons employed daily in the Indian Coal-fields during 1908 and 1909.*

| — | No. of persons employed daily. | | *Output per person employed.* | No. of deaths by accident. | *Death-rate per 1,000 persons employed.* | Tons of coal raised per person killed. |
|---|---|---|---|---|---|---|
| | 1908. | 1909. | 1909. | | | |
| | | | Tons. | | | |
| Baluchistan | 1,069 | 1,105 | *47·5* | 3 | *2·7* | 17,483 |
| Bengal | 112,219 | 102,253 | *104·3* | 100 | *0·97* | 10,660 |
| Central India | 1,762 | 1,505 | *80·7* | 1 | *0·66* | 121,496 |
| Central Provinces | 2,900 | 2,911 | *81·8* | 2 | *0·68* | 119,050 |
| Eastern Bengal and Assam | 1,709 | 1,795 | *171·3* | 12 | *6·69* | 25,463 |
| Hyderabad | 7,047 | 8,517 | *52·0* | 8 | *0·94* | 55,361 |
| N. W. Frontier Province | 14 | 4 | *24·0* | .. | .. | .. |
| Punjab | 2,196 | 1,223 | *30·4* | 2 | *1·63* | 8,604 |
| Rajputana | 257 | 233 | *49·1* | .. | .. | .. |
| TOTAL | **129,173** | **119,546** | .. | **128** | .. | .. |
| *Average* | .. | .. | *99·3* | .. | *1·07* | *92,734* |

## Diamonds.

There was little change reported in the output of diamonds in 1909, the total productions being 147·35 carats, valued at £1,089, as against 140·75 carats, valued at £940, in 1908. But whereas in previous years the whole of the supply came from the Central Indian States, these have only produced 35·98 carats in the year under report, the balance of 111·37 carats having been obtained at Banaganpilli in the Karnul District, Madras Presidency, a diamantiferous locality reported on by Dr. W. King in 1872 (*Mem.* G. S. I., Vol. VIII, p. 96, *seq.*). On the other hand the value of the small output from Central India is very much higher than that from Madras, the few stones found accounting for £1,042, while the much larger quantity from Banaganpilli is valued at only £47.

**Labour.** The average number of persons employed daily in this industry is reported as 588 in Central India and 482 in Madras.

## Gold.

There was again a rise in the production of gold in India as shown in Table 10, but it has not yet reached the level of the early years of the last quinquennial period. The principal advance took place in Mysore, where production had been stationary for the two previous years; and there was an increased output in Burma, where the gold is obtained by dredging in the Irrawaddy at Myitkyina. All the other gold producing districts, however, show a falling off, and none appears to have been obtained in the Central Provinces, the production from which has been roughly estimated to amount to 150 ozs. annually for the previous five years.

TABLE 10.—*Quantity and Value of Gold produced in India during 1908 and 1909.*

| PROVINCE. | 1908. | | 1909. | | Average No. of persons employed daily. |
|---|---|---|---|---|---|
| | Quantity. | *Value.* | Quantity. | *Value.* | |
| | Ounces. | £ | Ounces. | £ | |
| *Bombay*— | | | | | |
| Dharwar . . . . | 7,242 | *27,158* | 5,616 | *21,331* | 1,750 |
| *Burma*— | | | | | |
| Myitkyina . . . . | 7,950 | *30,600* | 8,445 | *32,730* | 209 |
| Katha and Pakokku . | 150(*a*) | *600* | 44 | *135* | |
| *Hyderabad* . . . . | 16,437 | *62,550* | 15,241 | *57,416* | 2,220 |
| *Jammu and Kashmir* . . | .. | .. | 4 | *15* | Not reported. |
| *Mysore* . . . . | 535,653 | *2,055,567* | 545,309 | *2,092,605* | Do. |
| *Punjab* . . . . . | 195 | *759* | 154 | *621* | 329 |
| *United Provinces* . . | 3 | *13* | 3 | *13* | Not reported. |
| TOTAL . | 567,630 | *2,177,247* | 574,816 | *2,204,866* | .. |

(*a*) Rough average estimate.

## Graphite.

The production of graphite in Travancore State, whence the whole of the Indian output is derived, was slightly higher than in 1908, being 3,132 tons as against 2,873 tons in the former year. The value, however, shows a considerable falling off, being £12,529 in 1909 as compared with £14,365 in 1908. The average number of persons employed daily at the Travancore mines was 763 in 1909.

## Iron-ore.

There was a considerable advance in the quantity of iron-ore raised in India during 1909, from 72,300 tons, valued at £15,149, in 1908, to 83,456 tons, valued at £16,563. Of the total amount, Bengal produced 72,711 tons and Burma 7,480 tons. There had been a considerable increase in the number of native furnaces worked in the Central Provinces between the years 1905 and 1908, the total rising from 276 to 626, which seems to indicate that the native smelters were making a strenuous effort to compete with imported iron, but in the year under review the number fell to 459. The shrinkage is attributed to the higher cost of labour and of working the furnaces, the payment of heavy royalties for fuel, and the competition of imported iron, though the local product is said to be superior for certain purposes.

## Jadeite.

The quantity of jadeite exported from Rangoon in 1908-09, *viz.*, 4,088 cwt., valued at £84,450, was practically the same as in 1907-08, but the price of the mineral rose from £18·59 per cwt. to £20·66 per cwt. The returns from the Myitkyina District, where the jadeite mines are situated, show that the quantity *extracted* in 1909 was only 2,487 cwt., valued at £14,892, or £6 per cwt., in spite of the fact that the right to collect the royalty was sold for a higher sum than before. The figures furnished by the licensee are probably not reliable.

## Magnesite.

Only 737 tons of magnesite, valued at £196, were mined in the Salem District, Madras, as compared with 7,534 tons, valued at

£2,009, produced in 1908. The output of this mineral has been subject to severe fluctuations since the industry was started in 1902, having fallen as low as 186 tons in 1907, probably because a secure market has not yet been found.

## Manganese-ore.

The returns of the production of manganese-ore are shown in Table 11. Four of the provinces show a decrease in output, but this is partially balanced by the rise in Bengal, due to the further opening up of the deposits in the Gangpur State, and in Madras, where extensive deposits are being worked in the Sandur State. Table 12 gives the production in the districts of the Central Provinces.

**Exports.**

The exports of manganese-ore amounted to 467,276 tons as against 427,454 tons in the previous year.

**Labour.**

The returns for labour employed in the manganese industry are not complete. In the Central Provinces the average number of persons employed daily is reported to be 10,947; in Madras 5,451; and in Bombay 651.

TABLE 11.—*Output of Manganese-ore for the years 1908 and 1909.*

| PROVINCE. | 1908. | | 1909. | |
|---|---|---|---|---|
| | Quantity. | *Value.* (*a*) | Quantity. | *Value.* (*a*) |
| | Tons. | £ | Tons. | £ |
| Bengal | 20,000 | *498,269* | 55,160 | *508,483* |
| Bombay | 23,232 | | 17,657 | |
| Central India | 13,315 | | 10,224 | |
| Central Provinces | 431,055 | | 381,285 | |
| Madras | 118,089 | | 138,454 | |
| Mysore | 68,624 | | 39,895 | |
| TOTAL | 674,315 | | 642,675 | |

(*a*) Represents the value of exports only (*vide* Table 1).

TABLE 12.—*Output of Manganese-ore in the Central Provinces during 1908 and 1909.*

| DISTRICT. | 1908. | 1909. |
|---|---|---|
| | Tons. | Tons. |
| **Balaghat** | 135,487 | 134,577 |
| **Bhandara** | 110,673 | 110,856 |
| **Chhindwara** | 49,008 | 17,464 |
| **Jabalpur** | 48 | .. |
| **Nagpur** | 135,839 | 118,388 |
| TOTAL | **431,055** | **381,285** |

## Mica.

The production of mica in India during 1909 shows a considerable falling off, which has affected each of the three producing provinces, as shown in Table 13.

TABLE 13.—*Production of Mica in 1908 and 1909.*

| PROVINCE. | *Average of preceding five years.* | 1908. | 1909. |
|---|---|---|---|
| | Cwt. | Cwt. | Cwt. |
| Bengal | *23,624* | 36,060 | 22,084 |
| Madras | *12,931* | 11,249 | 8,948 |
| Rajputana | *4,664* | 6,234 | 1,871 |
| TOTAL | *41,219* | **53,543** | **32,903** |

Ten thousand one hundred and seven persons are returned as having been employed daily in the industry, as against 15,277 in 1908.

**Exports.**

There was a rise in the exports of mica, from 27,572 cwt., valued at £139,513, in 1908, to 32,640 cwt., valued at £156,199, in 1909.

## Petroleum.

The output of petroleum in 1909 again surpassed all previous records, amounting to 233,678,087 gallons, an increase of 32 per cent. on the previous year. Practically the whole of the increased yield was due to greater activity in the Yenangyaung field in Upper Burma, as shown in Table 14, all the other producing districts in that province showing a decrease. In the case of the Yenangyat, Singu and Kyaukphyu fields this is said to be due to the gradual exhaustion of the oil sands, and in Akyab to the cancellation of one of the oil leases. No oil was produced in Thayetmyo during the year.

The exhaustion of the larger fields of Yenangyat and Singu is a serious matter, for it has concentrated attention on the much smaller, but as yet more productive field of Yenangyaung, where the output increased by 34 per cent.; and it is only a question of time, and that probably not very long, until this field also becomes unable to withstand the enormous drain now made upon it. In the meantime strenuous efforts are being made to discover other productive oil-fields by prospecting, but so far without complete success.

The output of the Assam oil-field shows only a slight increase, no new productive wells having been discovered in spite of active prospecting.

TABLE 14.—*Production of Petroleum during 1908 and 1909.*

| — | *Average of previous five years.* | 1908. | 1909. |
|---|---|---|---|
| | Gallons. | Gallons. | Gallons. |
| *Burma—* | | | |
| Akyab . . . . . . . . | *40,101* | 35,667 | 24,758 |
| Kyaukphyu . . . . . . . | *59.972* | 46,372 | 39,064 |
| Magwe (Yenangyaung) . . . . | *93,856,622* | 123,798,630 | 187,043,800 |
| Myingyan (Singu) . . . . . | *36,530,953* | 43,048.948 | 37,169,061 |
| Pakokku (Yenangyat) . . . . . | *13,094.562* | 6,472,545 | 6,119.934 |
| Thayetmyo . . . . . . . | *552* | 628 | *Nil* |
| *Eastern Bengal and Assam—* | | | |
| Digboi . . . . . . . . | *2,923,359* | 3,243,110 | 3,280,750 |
| *Punjab* . . . . . . . . | *1,089* | 420 | 720 |
| TOTAL . | *146,507,210* | **176,646,320** | **233,678,087** |

**Exports and Imports.**

The exports of petroleum during the year declined by over 50 per cent., the quantity being 2,265,649 gallons, valued at £28,556, compared with 5,729,114 gallons, valued at £38,304 in 1908. On the other hand there was a considerable rise in the exports of paraffin wax, the figures being 144,597 cwt., valued at £225,139, against 83,572 cwt., valued at £137,288 in 1908.

The imports of kerosine oil showed a reduction of 10 million gallons as compared with those of the previous year. Table 15 gives the sources of the oil imported.

TABLE 15.—*Imports of Kerosine Oil during 1908 and 1909.*

| COUNTRY OF ORIGIN. | 1908. | 1909. |
|---|---|---|
| | Gallons. | Gallons. |
| Borneo . . . . . . . . . | 8,179,838 | 6,970,796 |
| Roumania . . . . . . . . . . | 20,907,685 | 3.919,632 |
| Russia . . . . . . . . . . | 4,156,690 | 7,207,322 |
| Straits Settlements . . . . . . . | 7,889,601 | 8.128,978 |
| Sumatra . . . . . . . . . . | 8,181,049 | 4,740,131 |
| United States of America . . . . . . | 31,431,505 | 39,547,072 |
| Other Countries . . . . . . . . . | 646 | 448 |
| TOTAL . | **80,747,014** | **70,514,379** |

**Labour.**

The returns for labour on the oil-fields are not complete, but an average number of 3,571 persons is reported as having been employed daily on the Burmese fields.

## Ruby, Sapphire and Spinel.

The whole of the output of ruby, sapphire and spinel reported for 1909 was derived from the Burma Ruby Mines of Mogok, work at the Kashmir sapphire mines having been abandoned in 1908. The production of the Mogok mines was 205,384 carats of rubies,

13,457 carats of sapphires, and 39,463 carats of spinel, or a total of 258,304 carats, valued at £58,649, against 281,014 carats, valued at £83,505 in 1908. One thousand three hundred and eighty-five persons were employed on an average daily at the mines as compared with 1,140 in 1908.

## Salt.

The production of salt during the year 1909 was somewhat less than in 1908, but is slightly higher than the average of the preceding five years. Table 16 shows the output for each province, and Table 17 the production of rock-salt in Northern India. The imports of foreign salt amounted to 460,639 tons compared with 437,887 tons in the preceding year.

TABLE 16.—*Provincial Production of Salt for the years 1908 and 1909.*

| PROVINCE. | *Average of previous five years.* | 1908. | 1909. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Aden | *81,996* | 88,324 | 66,535 |
| Bengal | *45* | 48 | 34 |
| Bombay and Sind | *431,100* | 471,302 | 443,707 |
| Burma | *27,145* | 31,336 | 26,944 |
| Gwalior State | *267* | 437 | 183 |
| Madras | *389,317* | 435,120 | 309,583 |
| Northern India | *319,911* | 341,694 | 408,612 |
| TOTAL | *1,249,781* | 1,368,261 | 1,255,598 |

TABLE 17.—*Production of Rock-Salt during 1908 and 1909.*

| MINES. | *Average of previous five years.* | 1908. | 1909. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Salt Range . . . . . . . | *100,839* | 93,774 | 126,987 |
| Kohat . . . . . . . . | *15,655* | 16,049 | 15,875 |
| Mandi State . . . . . . . | *3,945* | 3,954 | 3,857 |
| TOTAL . | *120,439* | **113,777** | **146,719** |

## Saltpetre.

The quantity of saltpetre exported during 1909 was somewhat above the average for the preceding five years, being 404,946 cwt., valued at £296,838, against 358,939 cwt., valued at £265,135. The destination of the saltpetre exported is shown in Table 18.

TABLE 18.—*Distribution of Saltpetre exported during 1908 and 1909.*

| EXPORTED TO | 1908. | | 1909. | |
|---|---|---|---|---|
| | Quantity. | *Value.* | Quantity. | *Value.* |
| | Cwt. | £ | Cwt. | £ |
| China . . . . . . | 135,396 | *96,950* | 133,382 | *92,735* |
| France . . . . . | 14,065 | *9,866* | 28,530 | *19,624* |
| United Kingdom . . . | 96,181 | *70,049* | 81,503 | *57,321* |
| United States of America . | 77,632 | *70,279* | 84,096 | *73,296* |
| Other Countries . . . | 62,922 | *45,614* | 77,435 | *53,862* |
| TOTAL . | **386,199** | *292,758* | **404,946** | *296,838* |

## Silver-lead ore.

With the completion by the Burma Mines, Ltd., of the railway to the silver-lead mines of Bawdwin in the Northern Shan States of Burma towards the close of 1908, and the erection of smelters at Mandalay, this industry has been placed on a sound footing, and both lead and silver are now being regularly shipped from Rangoon, while the statistics of production of the ore, which is now mined on a large scale in the Shan States for mixing with the refractory lead slags from Bawdwin, are now being more carefully compiled than before. Another source of supply, recently developed, is Mount Pima in the Yamethin District, the ore from which, after concentration, is sold for smelting to the Burma Mines, Ltd. The production of these ores is shown in Table 19.

**Imports.**

The imports of lead during 1909 amounted to 6,872 tons, worth £128,036, as compared with 6,809 tons, worth £131,549 in 1908. Of this amount 3,134 tons in 1909, against 2,973 tons in 1908, were imported in the form of sheet lead for packing tea.

TABLE 19.—*Production of Silver-lead ore in Burma during 1909.*

| DISTRICT. | Quantity. | Bullion shipped to London. Lead. | Bullion shipped to London. Silver. | *Amount realised by sale of bullion.* |
|---|---|---|---|---|
| | Tons. | Tons. | Ounces. | £ |
| Mandalay | 2 | 5,030 | 27,500 | *68,100* |
| N. Shan States—Bawdwin | 485(*a*) | | | |
| N. Shan States—Namun | 5,888 | | | |
| S. Shan States | 90 | | | |
| Yamethin—Mount Pima | 2,463·5 | | | |
| TOTAL | 8,928·5 | 5,030 | 27,500 | *68,100* |

(*a*) In addition 11,850 tons of lead slag were transported from Bawdwin to the smelters at Mandalay.

## Tin-ore.

The amount of tin ore produced in Burma was less than in the previous year, being 1,665 cwts. from Mergui and 7 cwts. from Tavoy, against 1,876 and 30 cwts. respectively in 1908. The figures show no material change, the average output of the preceding five years having been 1,635 cwts. One hundred persons are returned as having been employed daily on the average in the two districts.

**Imports.**

The imports of block tin in 1909 amounted to 37,477 cwt., valued at £283,898, against 38,383 cwt., valued at £294,465 in 1908.

## III.—MINERALS OF GROUP II.

The following notes deal with those minerals for which the returns are admittedly not complete, or are only approximately estimated.

**Alum.**

The output of alum in the Mianwali District, Punjab, was more than doubled, 4,629 cwt. having been produced in 1909, valued at £1,995, as compared with 2,204 cwt., valued at £1,000, in the previous year. This amount, however, was below the average of the preceding five years, the industry being subject to considerable fluctuations. The imports of alum were also higher, 74,419 cwt. in 1909, and 70,348 cwt. in 1908.

**Amber.**

Only 31 cwt. of amber are returned as having been mined in the Myitkyina District in Upper Burma, as compared with an average for the preceding five years of 104 cwt. The value is returned as £287. In 1908 the output was 49 cwt., worth £364.

**Antimony.**

No antimony ore is returned as having been obtained during 1909 from the mine at the Shigri glacier in Lahaul, referred to in the Quinquennial Review. A small quantity, 2½ tons, worth £1 a ton, is said to have been mined in the S. Shan States.

**Bauxite.**

In the Jubbulpore district, Central Provinces, 32 tons of bauxite were extracted, valued at £12.

**Borax.**

The quantity of borax exported from India during 1909 was 5,073 cwt., valued at £6,474, as compared with an average of 4,959 cwt., valued at £6,568, for the preceding five years. None of the borax exported is produced in British India, but is brought across the frontier from Tibet.

**Building materials.**

The most complete returns for building materials are received from Burma. The enormous rise shown in the returns for that province with respect to granite and gneiss is due to the opening of large quarries in the Thatôn District for the supply of stone to Rangoon, where extensive training works are in progress for the improvement of the port, and for use as road metal in place of the Deccan Trap formerly imported from Bombay. The Trap rock quarried in the Bassein and Ruby Mines Districts and most of the sandstone extracted is also used for metalling roads. The returns received from the various provinces are shown in Table 20.

The quantity of stone and marble imported during 1909 was 12,988 tons, against 13,214 tons in 1908. Bricks and tiles to the value of £79,871, were also imported, as well as 104,548 tons of cement, valued at £270,425.

**Clays.**

Returns were received only from Burma and the Central Provinces. In Burma the amount of clay extracted was 1,123,347 tons, mainly for brick making, valued at £39,322. In the Central Provinces 10,214 tons of clay, worth £319, were extracted and 97 tons of Fuller's Earth, worth £32, used in the manufacture of pottery.

**Copper.**

Active prospecting operations for copper ores are still proceeding in Singhbhum and Sikkim, but the concerns have not yet reached the producing stage. Seven tons of copper ore are returned as having been raised in Singhbhum during the year, but the value is not given.

**Corundum.**

The output of corundum in the Rewah State is reported as only 19 tons, valued at £103, against 36·3 tons in 1908. A small quantity, valued at £6, was also raised in Hyderabad.

**Garnet.**

The garnets mined in the Kishengarh State in Rajputana amounted to 384 cwt., valued at £2,884, in 1909, a considerable advance on the figures for 1908. In Ajmere only 9 cwt. were produced, valued at £97, against 32 cwt., worth £168, in 1908.

TABLE 20.—*Production of Building Materials in India during 1909.*

| PROVINCE. | NATURE OF MATERIAL. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GRANITE AND GNEISS | | LATERITE. | | LIMESTONE. | | MARBLE. | | SANDSTONE. | | SLATE. | | TRAP ROCK. | |
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | Tons. | £ | Tons. | £ | Tons. | £ | Tons. | £ | Tons. | £ | Tons. | £ | Tons. | £ |
| Baluchistan | .. | .. | .. | .. | 466 | *845* | .. | .. | .. | .. | .. | .. | .. | .. |
| Bengal | .. | .. | .. | .. | 42,000 | *1,400* | .. | .. | .. | .. | 1,518 | *1,876* | .. | .. |
| Burma | 7,733,855 | *465,855* | 302,938 | *20,993* | 104,797 | *11,397* | .. | .. | 316,812 | *9,478* | 26 | *3* | 27,846 | *4,281* |
| Central India | .. | .. | .. | .. | 54,399 | *3,853* | .. | .. | .. | .. | .. | .. | .. | .. |
| Central Provinces | .. | .. | .. | .. | 56,002 | *3,570* | .. | .. | .. | .. | .. | .. | .. | .. |
| E. Bengal and Assam | .. | .. | .. | .. | 95,973 | *6,867* | .. | .. | .. | .. | .. | .. | .. | .. |
| Madras (Coorg) | 20,224 | *4,045* | 119 | *8* | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Punjab | .. | .. | .. | .. | 500 | *47* | .. | .. | .. | .. | 5,631 | *5,611* | .. | .. |
| Rajputana | .. | .. | .. | .. | 29,223 | *3,540* | 1,963(*a*) | *1,247* | 255 | *30* | .. | .. | .. | .. |
| United Provinces | .. | .. | .. | .. | .. | .. | .. | .. | 154,945 | *17,881* | 6,143 | *658* | .. | .. |
| **TOTAL** | **7,754,079** | *469,900* | **303,057** | *21,001* | **383,360** | *31,429* | **1,963** | *1,247* | **472,012** | *27,389* | **13,318** | *8,148* | **27,846** | *4,281* |
| Total production in 1908 | 357,308 | *22,396* | 247,839 | *25,775* | 410,493 | *30,488* | 1,758 | *1,316* | 175,313 | *18,107* | Returns not complete | *14,312* | .. | .. |
| Average of preceding five years | 102,132 | *9,323* | 237,453 | *25,997* | 354,708 | *28,236* | *1,718* | *1,483* | 152,578 | *19,068* | .. | *10,751* | .. | .. |

(*a*) From the Makrana quarries in Jodhpur State.

**Tourmaline.** The tourmaline mining industry in Upper Burma is practically extinct. In the N. Shan States seven stones are reported to have been found, valued at £26.

**Ochres.** The yellow ochre mine at Jauli, in the Jubbulpore District, belonging to Messrs. Olpherts & Co., was not worked during the year. In Central India 14 tons of red ochre, valued at £3, are said to have been extracted.

**Steatite.** The output at the steatite mines near the Marble Rocks in Jubbulpore, opened by Messrs. P. C. Dutt and Burn & Co. in 1907, was 564 tons, valued at £769, against 764 tons, valued at £1,019, in 1908. In Burma 4 tons were extracted in the Pakokku Hill Tracts and 14 tons in the Minbu District, the total value being returned as £477. A small quantity, valued at £11, was also obtained in Hyderabad.

**Tungsten.** The output of wolfram at Agargaon in the Nagpur District was 4 cwt., and in Mergui in Lower Burma, where it is found associated with the tin ore in alluvial deposits, 140 cwt. The value of the mineral is not reported.

## IV.—STATEMENT OF MINERAL CONCESSIONS GRANTED DURING 1909.

### BALUCHISTAN.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Kalat | (1) Rai Sahib Rocharam & Sons, Abbottabad. | Coal | P. L. | 490 | 30th April 1909. | 1 year. |
| Do. | (2) Sirdar Bahawal Khan Satik Zai. | Do. | M. L. | 160 | 1st July 1909 | 30 years. |
| Quetta-Pishin | (3) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Chromite | M. L. | 80 | 1st July 1908 | Do. |
| Do. | (4) Do. do. | Do. | M. L. | 80 | Do. | Do. |
| Do. | (5) Do. do. | Do. | M. L. | 80 | Do. | Do. |
| Do. | (6) Mr. W. C. Clements | Do. | M. L. | 80 | 1st July 1909 | Do. |
| Do. | (7) Mr. E. G. Foley | Coal | M. L. | 290 | 1st July 1908 | Do. |
| Do. | (8) Do. do. | Do. | P. L. | 8,960 | 6th May 1909 | 1 year. |
| Do. | (9) Messrs. Alibhoy & Bros. | Do. | M. L. | 80 | 1st January 1909. | 30 years. |
| Do. | (10) Messrs. E. G. Foley, W. C. Clements and Colonel A. G. Newcomen. | Do. | P. L. | 3,840 | 21st July 1909. | 1 year. |
| Sibi | (11) Colonel A. Gleadowe Newcomen, Mr. E. G. Foley and Mr. W. C. Clements. | Do. | M. L. | 160 | 1st July 1909 | 30 years. |
| Do. | (12) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (13) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (14) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (15) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (16) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (17) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (18) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (19) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (20) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (21) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (22) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (23) Do. do. | Do. | M. L. | 160 | Do. | Do. |
| Do. | (24) Do. do. | Do. | M. L. | 160 | Do. | Do. |

E. L. denotes Exploring License ; P.L., Prospecting License ; and M.L., Mining Lease.

## BALUCHISTAN—*contd.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Sibi . . | (25) Colonel A. Gleadowe Newcomen, Mr. E. G. Foley and Mr. W. C. Clements. | Coal . . . | M. L. . | 160 | 1st July 1909 | 30 years. |
| Do. . | (26) Do. do. . | Do. . . . | M. L. . | 160 | Do. . | Do. |
| Do. . . | (27) Khan Bahadur Burjorjee D. Patel, C.I.E. | Do. . . . | P. L. . | 1,280 | 2nd July 1909. | 1 year. |
| Zhob . . | (28) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Chromite . . | M. L. . | 80 | 1st July 1908 | 30 years. |
| Do. . . | (29) The Baluchistan Mining Syndicate. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (30) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (31) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (32) Mr. W. C. Clements | Do. . . | M. L. . | 80 | 1st July 1909 | Do. |
| Do. . . | (33) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (34) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (35) Baluchistan Mining Syndicate. | Do. . . | M. L. . | 80 | 1st July 1908 | Do. |
| Do. . . | (36) Do. do. . | Do. . . | M. L. . | 160 | Do. . | Do. |
| Do. . . | (37) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (38) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (39) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (40) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (41) Do. do. . | Do. . . | M. L. . | 240 | Do. . | Do. |
| Do. . . | (42) Do. do. . | Do. . . | M. L. . | 240 | Do. . | Do. |
| Do. . . | (43) Do. do. . | Do. . . | M. L. . | 132 | Do. . | Do. |
| Do. . . | (44) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (45) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (46) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (47) The Baluchistan Mining Syndicate. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (48) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (49) Do. do. . | Do. . . | M. L. . | 240 | Do. . | Do. |
| Do. . . | (50) Do. do. . | Do. . . | M. L. . | 214 | Do. . | Do. |
| Do. . . | (51) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## BALUCHISTAN—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Zhob . . | (52) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Chromite . . | M. L. . | 80 | 1st July 1908 | 30 years. |
| Do. . . | (53) The Baluchistan Mining Syndicate. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (54) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do |
| Do. . . | (55) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (56) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (57) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (58) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (59) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (60) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (61) Baluchistan Mining Syndicate. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (62) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (63) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (64) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (65) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (66) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (67) Do. do. . | Do. . . | M. L. . | 160 | Do. . | Do. |
| Do. . . | (68) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (69) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (70) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (71) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (72) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (73) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (74) Do. do. . | Do. . . | M. L. . | 80 | 1st July 1909 | Do. |
| Do. . . | (75) Do. do . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (76) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (77) Do. do. . | Do. . . | M. L. . | 84 | Do. . | Do. |
| Do. . . | (78) Do. do. . | Do. . . | M. L. . | 160 | Do. . | Do. |
| Do. . . | (79) Do. do . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (80) Do. do. . | Do. . . | M. L. . | 80 | 1st January 1910. | Do. |
| Do. . . | (81) Do. do. . | Do. . . | M. L. . | 82 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## BALUCHISTAN—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Zhob . . | (82) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Chromite . . | M. L. . | 183 | 1st July 1909 | 30 years. |
| Do. . . | (83) Do. do. . | Do. . . | M. L. . | 80 | 1st January 1910. | Do. |
| Do. . | (84) Do. do. . | Do. . . | M. L. . | 80 | 1st July 1909 | Do. |
| Do. . . | (85) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (86) Khan Bahadur Burjorjee D. Patel, C.I.E. | Do. . . | M. L. . | 115 | 1st January 1910. | Do. |
| Do. . . | (87) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (88) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (89) Babu Karam Singh, Agent of Mr. C. R. Lindsey. | Do. . . | M. L. . | 80 | 1st July 1909 | Do. |
| Do. . . | (90) Do. do. . | Do. . . | M. L. . | 160 | Do. . | Do. |
| Do. . . | (91) Do. do. . | Do. . . | M. L. . | 175·37 | Do. . | Do. |
| Do. . . | (92) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (93) Do. do. . | Do. . . | M. L. . | 80 | 1st January 1910. | Do. |
| Do. . . | (94) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (95) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (96) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (97) Khan Bahadur Burjorjee D. Patel, C.I.E. | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (98) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |
| Do. . . | (99) Do. do. . | Do. . . | M. L. . | 80 | Do. . | Do. |

## BENGAL.

| | | | | | | |
|---|---|---|---|---|---|---|
| Hazaribagh . | (100) S. D. Philippe, Esq. | Mica . . . | P. L. . | 40 | 9th January 1909. | 1 year. |
| Do. . | (101) Messrs. Gladstone, Wyllie & Co. | Minerals other than mica, coal, oil, gold, silver and precious stones. | P. L. . | 1,600 | 28th April 1909. | Do. |
| Do. . | (102) Do. do. . | Do. . . | P. L. . | 400 | Do . | Do. |
| Do. . | (103) Lachmi Narain Shraff. | Mica . . . | P. L. . | 160 | 30th July 1909. | Do. |
| Do. . | (104) Archibald A. C. Dickson, Esq. | Do. . . | P. L. . | 160 | 15th July 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## BENGAL—*contd.*

| DISTRICT. | Grantee. | Mineral | Nature of grant. | Area of acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Hazaribagh | (105) S. D. Philippe | Mica | P. L. | 10 | 8th November 1909. | 1 year. |
| Do. | (106) Satyendro Pado Sarkar. | Do. | P. L. | 300 | 2nd October 1909. | Do. |
| Sambalpur | (107) A. H. Tietkins, Local Agent, Sambalpur. | Coal | P. L. | 424·38 | 14th December 1909. | Do. |
| Singhbhum | (108) Messrs. Martin & Co. of Calcutta. | Chromite | P. L. | 2,291·20 | 6th July 1909 | Do. |
| Do. | (109) Mr. P. N. Bose, Ranchi. | Gold | P. L. | 2,240 | 30th September 1909. | 2 years. |
| Do. | (110) The Bengal Iron and Steel Company, Limited, 6 and 7, Clive Street, Calcutta. | Iron ore | M. L. | 1,920 | 6th December 1909. | 30 years. |
| Do. | (111) J. A. Joseph of Calcutta. | Manganese | P. L. | 2,112 | 3rd December 1909. | 1 year. |

## BOMBAY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Belgaum | (112) Mr. N. H. Patuck of Bombay. | Manganese | P. L. | 263 | 17th February 1909. | 1 yea . |
| Do. | (113) Do. do. | Do. | E. L. | 2,238 | Do. | Do. |
| Do. | (114) Mr. C. P. Boyce of Belgaum. | Do. | P. L. | 1,207 | 21st September 1909. | Do. |
| Do. | (115) Do. do. | Do. | P. L. | 102 | Do. | Do. |
| ijapur | (116) Messrs. C. Chatoorbhooj & Co., Bombay. | Asbestos | P. L. | 765 | 19th February 1909. | Do. |
| Do. | (117) Mr. Shapurji China of Hyderabad (Deccan). | Gold | P. L. | 1,992 | 4th January 1909. | Do. |
| hárwár | (118) The Gold Fields of Dharwar (India), Limited. | Do. | M. L. | 282 | 1st June 1909 | 30 years. |
| Do. | (119) The Dharwar Gold Mines, Ltd. | Do. | M. L. | 2,101 | 20th August 1909. | Do. |
| nara | (120) Messrs. N. Futehally & Co. | Manganese, tin, copper; chrome and naphtha. | P. L. | 2,622 | 19th March 1909. | 1 year. |
| Do. | (121) Mr. Sambshiva Iyer. | Manganese | P. L. | 180 | 18th March 1909. | Do. |
| Do. | (122) Mr. C. P. Boyce | Asbestos | E. L. | 20 | 8th November 1909. | Do. |
| ch Maháls | (123) Mr. F. A. H. East, Manager, Shivrájpur Syndicate. | Manganese. | M. L. | 401 | 26th October 1909. | 30 years. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L. Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Ratnagiri . | (124) Mr. E. N. Leslie . | Mica . . . | E. L. . | 2,560 | 15th April 1909. | 1 year. |
| Do. . | (125) Do. do. . | Mica and coal . | P. L. . | 475 | Do. . | Do. |
| Do. . | (126) Messrs. W. Whelan Coen & Co. | Chromium . . | P. L. . | 508 | 1st April 1909 | Do. |
| Do. . | (127) Do. do. . | Do. . . | E. L. . | 2,560 | 15th April 1909. | Do. |
| Do. . | (128) Messrs. Nansee Khairaz & Co. | Graphite, copper and gold. | P. L. . | 632 | 27th April 1909. | Do. |

## BURMA.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Akyab . . | (129) (1) U. Thu Taw U. (2) U. Aung Ban . | Coal . . . | E. L. . | 20,000 approximately. | 8th October 1909. | 1 year. |
| Amherst . | (130) Messrs. Foucar and Co. | Antimony . . | P. L. . (renewal) | 309·14 | 27th June 1909. | Do. |
| Do. . | (131) C. Ramalingan Pillay. | Minerals . . | E. L. . | Different parts of the Amherst District in unoccupied and unreserved land belonging to Government, excluding Forest Reserves. | 7th September 1909. | Do. |
| Bhamo . . | (132) Mr. A. C. Macmillan. | Gold . . . | M. L. . | 1,568 | 1st August 1908. | 30 years. |
| Henzada . | (133) Mr. F. L. Phipps . | Oil . . . | P. L. . . | 1,920 | 4th March 1909. | 1 year. |
| Do. . | (134) Bombay Burma Coal Syndicate. | Coal . . . | P. L. . (renewal) | 2,560 | 19th April 1909. | Do. |
| Do. . | (135) Messrs. Gillanders, Arbuthnot & Co. | Do. . . . | P. L. . (renewal) | 2,560 | Do. . | Do. |
| Katha . . | (136) Mr. J. A. Manyon | Copper . . | P. L. . | 2,880 | 11th June 1909. | Do. |
| Lower Chindwin. | (137) Mr. W. Macdonald | Iron pyrites, sulphide of iron ore. | P. L. . | 14·09 | 18th November 1909. | Do. |
| Magwe . . | (138) Maung Maung Gyi. | Petroleum . . | P. L. . | 383 | 29th March 1909. | Do. |
| Do. . . | (139) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . | P. L. . (renewal) | 12,800 | 1st May 1909 | Do. |

E. L. denotes Exploring License; P. L., Prospecting License and M. L., Mining Lease.

BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Magwe . | (140) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Petroleum . | P. L. (renewal) | 1,280 acres, blocks 38. and 48. | 28th April 1909. | 1 year. |
| Do. . | (141) Sulaiman Adamji . | Do. | P. L. (renewal) | 1,280 acres, blocks 58. and 68. | 4th June 1909 | Do. |
| Do. . | (142) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. | M. L. | 688 | 1st January 1909. | 30 years. |
| Mandalay . | (143) Messrs. Bewick, Moreing & Co. | Minerals of all descriptions other than mineral oil. | P. L. (renewal) | 484·8 | 20th January 1909. | 1 year. |
| Do. . | (144) Messrs. Mower & Co. | Copper, gold, lead, silver, arsenic, and antimony. | P. L. | 2,560 | 8th May 1909 | Do. |
| Do. . | (145) Do. do. . | Lead, silver and copper. | P. L. | 2,560 | Do. | Do. |
| Do. . | (146) Do. do. . | Silver and associated metals. | P. L. | 1,280 approximately. | 2nd December 1909. | Do. |
| Meiktila . | (147) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Petroleum . | P. L. | 7,680 | 10th March 1909. | Do. |
| Do. . | (148) Mr. A. Campbell-Macmillan. | Lead and copper . | P. L. | 1,280 | 30th June 1909. | Do. |
| Do. | (149) Do. do. . | Do. do. . | P. L. | 1,280 | Do. | Do. |
| Do. . | (150) Dewalachi Galena Syndicate. | Coal . . . | P. L. | 2,880 | 25th November 1909. | Do. |
| Mergui . | (151) Anglo-Continental Gold Syndicate. | Tin . . . | P. L. (renewal) | 6,362·88 | 20th February 1909. | 2 years. |
| Do. . . | (152) Mr. A. E. Laudon White, on behalf of Lieutenant-Colonel K. M. Foss. | Coal . . . | E. L. | 48 | 22nd January 1909. | 1 year. |
| Do. . . | (153) Messrs. Gillanders, Arbuthnot & Co., on behalf of Mr. Hammersley Heenan. | Do. . . . | P. L. | 2,611·2 | 24th July 1909 | Do. |
| Do. . . | (154) Mr. A. R. Finlay . | Tin and gold . | P. L. | 1,600 | 5th July 1909 | Do. |
| Do. | (155) Do. do. . | Do. . | P. L. | 3,200 | Do. | Do. |
| Do. . . | (156) Do. do. . | Do. . | P. L. | 1,600 | Do. | Do. |
| Do. . . | (157) Do. do. . | Do. . | P. L. | 1,600 | Do. | Do. |
| Do. . . | (158) Do. do. . | Do. . | P. L. | 1,600 | Do. | Do. |
| Do. . . | (159) Do. do. . | Do. . | P. L. | 1,600 | Do. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Te[r] |
|---|---|---|---|---|---|---|
| Mergui . . | (160) Mr. A. R. Finlay . | Tin and gold . | P. L. . | 1,600 | 5th July 1909 | 1 year. |
| Do. . . | (161) Do. do. . | Do. . | P. L. . | 1,600 | Do. . | Do. |
| Do. . . | (162) Do. do. . | Do. . | P. L. . | 1,600 | Do. . | Do. |
| Minbu . . | (163) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Petroleum . . | P. L. (renewal) | 1,600 | 1st January 1909. | Do. |
| Do. . . | (164) Do. do. . | Do. . . | P. L. (renewal) | 2,880 | 1st April 1909. | Do. |
| Do. . . | (165) Moolla Dawood, Sons & Co. | Do. . . | E. L. . | 2,880 | 8th October 1909. | Do. |
| Myingyan . | (166) Messrs. J. W. Darwood & Co. | Do. . . | P. L. . | 320 | 1st February 1909. | Do. |
| Do. . | (167) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 1,320 | 28th January 1909. | Do. |
| Do. . | (168) Messrs. A. S. Jamal Brothers & Co. | Do. . . | P. L. . | 640 | 17th February 1909. | Do. |
| Do. . | (169) Do. do. . | Do. . . | P. L. . | 1,280 | Do. . | Do. |
| Do. . | (170) Mr. J. W. Parry . | Do. . . | E. L. . | 2,560 | 14th January 1909. | Do. |
| Do. . | (171) Do. do. . | Do. . . | E. L. . | 5,120 | Do. . | Do. |
| Do. . | (172) Rangoon Oil Co. . | Do. . . | P. L. . | 640 | 15th February 1909. | Do. |
| Do. . | (173) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 3,504 | 4th October 1908. | Do. |
| Do. . | (174) Do. do. . | Do. . . | P. L. . | 1,283 | 15th September 1908. | Do. |
| Do. . | (175) Moolla Ahmed . | Do. . . | P. L. . | 1,250 | 29th May 1909 | Do. |
| Do. . | (176) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 7,680 | 1st May 1909 | Do. |
| Do. . | (177) Mr. J. W. Parry . | Do. . . | E. L. . | 2,560 | 1st November 1909. | Do. |
| Do. . | (178) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 1,280 | 15th September 1909. | Do. |
| Myitkyina . | (179) Mr. A. R. Oberlander. | Copper, silver, iron and sulphur. | P. L. . | 640 | 11th November 1909. | Do. |
| Northern Shan States. | (180) Mr. R. S. Dickie . | Lead and silver . | P. L. . | 640 | 17th March 1909. | Do. |
| Do. . | (181) Burma Mines, Ltd. | Coal . . . | P. L. . | 502·656 | 4th May 1909 | Do. |
| Do. . | (182) Do. do. . | Lead, copper, zinc, nickel, cobalt, silver and gold. | P. L. . | 312 | 27th May 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Pakôkku . | (183) Rangoon Oil Co. . | Petroleum . . | P. L. . | 1,280 | 7th February 1909. | 1 year. |
| Do. . | (184) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 640 | 1st January 1909. | Do. |
| Do. . | (185) Do. do. . | Do. . . | P. L. (renewal) . | 2,560 | 9th October 1908. | Do. |
| Do. . | (186) Maung Kyaw Zan | Do. . . | E. L. . | Over areas near Tazu village. | 14th January 1909. | Do. |
| Do. . | (187) M. Goolam Hussein | Do. . . | P. L. . | 1,920 | 15th July 1909. | Do. |
| Do. . | (188) Do. do. . | Do. . . | P. L. . | 1,280 | 21st July 1909 | Do. |
| Do. . | (189) Maung Kyaw Zan | Do. . . | E. L. . | Over areas near Tazu and Okhmin villages, Pauk Township. | 14th June 1909. | Do. |
| Do. . | (190) Maung Po Thaik . | Do. . . | M. L. . | Undemarcated blocks Nos. 3 and 4. | 1st September 1909. | 30 years. |
| Do. . | (191) Maung Shwe Goh . | Do. . . | P. L. . | 1,280 | 22nd December 1909. | 1 year. |
| Do. . | (192) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | P. L. . | 2,240 | 11th November 1909. | Do. |
| Do. . | (193) Mr. A. W. G. Bleeck, on behalf of Messrs. Mower & Co. | Do. . . | P. L. . | 4,480 | 22nd December 1909. | Do. |
| Do. . | (194) Maung Shwe Goh | Do. . . | P. L. . | 2,240 | Do. . | Do. |
| Do. . | (195) Maung Mu . . | All minerals . | E. L. . | Saw Township | 4th November 1909. | Do. |
| Prome . . | (196) Mr. W. B. E. Rule | Mineral oil . . | P. L. . | 10,496 | 3rd June 1909 | Do. |
| Do. . . | (197) Mr. Benjamin Gallsworthy. | Petroleum . . | P. L. . | 19,884·8 | 6th August 1909. | Do. |
| Sagaing . | (198) Mr. S. Spencer, on behalf of the Burma Mines, Ltd. | Iron ore . . | P. L. . | 550·96 | 3rd August 1909. | Do. |
| Salween . | (199) Mr. A. H. Rowland Ady. | Galena and lead . | P. L. . | 2,560 | 1st July 1909 | Do. |
| Do. . | (200) Mr. G. E. Hayes . | Silver and lead . | P. L. . | 3,200 | 23rd September 1909. | Do. |
| Shwebo . | (201) Mr. C. D. Clark, Manager for the Burma Mines, Ltd. | Iron . . . | P. L. . | 320 | 1st July 1909 | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Southern Shan States. | (202) Htamong Ye and Saya Kyi. | Silver and lead . | M. L. . | 7·38 | 1st June 1908 | 5 years. |
| Do. . | (203) Mr. F.H. Parry, on behalf of the Dewalachi Galena Syndicate. | Lead, copper and other minerals. | P. L. . | 3,200 | 29th June 1909. | 1 year. |
| Do. . | (204) Messrs. Mower & Co. | Wolfram . . | P. L. . | 2,560 | 7th July 1909 | Do. |
| Do. . | (205) Mr. T. Fowle . | Copper, galena and other ores. | P. L. . | 3,200 | 26th August 1909. | Do. |
| Do. . | (206) Messrs. Mower & Co. | Wolfram . . | P. L. . | 2,560 | 25th August 1909. | Do. |
| Do. . | (207) Mr. F. H. Parry, on behalf of the Dewalachi Galena Syndicate. | Copper, etc. . | P. L. . | 1,609 | Do. . | Do. |
| Tavoy . . | (208) Ko Tun Byaw, Attorney of Mr. A. C. Martine, Rangoon. | Minerals of every description. | E. L. . | Whole district | 31st May 1909 | Do. |
| Do. . . | (209) Mr. J. W. Donaldson Aiken. | Tin, wolfram, gold and galena. | P. L. . | 2,880 | 14th August 1909. | Do. |
| Do. . . | (210) Mr. R. B. Levien . | Tin and other minerals. | P. L. . | 640 | 7th October 1909. | Do. |
| Thaton . . | (211) Mr. G. E. Hayes . | Gold and other minerals. | P. L. . | 3,200 | 19th March 1909. | Do. |
| Do. . . | (212) Messrs. Mower & Co. | Gold, silver, copper, iron and pyrites. | P. L. . | 3,200 | 7th April 1909 | Do. |
| Do. . . | (213) Do. do. . | Silver and lead . | P. L. . | 2,560 | 27th November 1908. | Do. |
| Thayetmyo . | (214) Messrs. Bawaney Brothers & Co. | Petroleum . . | E. L. . | 2,560 | 19th April 1909. | Do. |
| Do. . | (215) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Do. . . | E. L. . | 41,002 | 9th July 1909 | Do. |
| Do. . | (216) Maung Po Ni . | Do. . . | E. L. . | 6·33 | 29th July 1909. | Do. |
| Do. . | (217) Maung Tun Aung Gyaw. | Do. . . | E. L. . | 29·34 | 11th October 1909. | Do. |
| Do. . | (218) Chiew Bah Ghone . | Do. . . | E. L. . | 9,661 | Do. . | Do. |
| Do. . | (219) Maung Tun Aung Gyaw. | Do. . . | E. L. . | 9,356·8 | 28th October 1909. | Do. |
| Do. . | (220) Shamuddin . . | Do. . . | E. L. . | 8,876·8 | 6th November 1909. | Do. |
| oungoo . | (221) Mr. A. R. Ady . | Silver, lead and other metals. | P. L. . | 1,349 | 13th March 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## BURMA—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Toungoo . | (222) Mr. C. E. Brown . | Silver, lead and other metals. | P. L. . (renewal) | 3,200 | 30th October 1906. | Renewed on the 28th October 1909 till 30th April 1910. |
| Do. . | (223) Mr. N. Samwell . | Gold . . . | E. L. . (renewal) | Shwegyin river and its tributaries on the east of the Sittang river. | 10th December 1908. | Renewed for 1 year on the 20th December 1909. |
| Upper Chindwin. | (224) The Petroleum Syndicate, by its Manager, Major H. W. Iles. | Petroleum . . | P. L. . | 5,760 | 26th March 1909. | 1 year. |
| Do. . | (225) Mr. W. A. Freymuth, on behalf of the Burma Mines Development and Agency, Ltd. | Coal . . . | M. L. . | 1,920 | 1st July 1908 | 30 years. |

## CENTRAL PROVINCES.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Akola . . | (226) Mr. Madho, son of Balkrishna Bawne. | All minerals . | E. L. . | 1,920 | 10th July 1909 | 1 year. |
| Balaghat . | (227) Mr. D. Laxminarayan, Kamptee. | Manganese . . | M. L. . | 116 | 18th January 1909. | 30 years. |
| Do. . | (228) Mr. M. M. Mullna . | Do. . . | P. L. . | 120 | 29th March 1909. | 1 year. |
| Do. . | (229) Mr. D. Laxminarayan. | Do. . . | M. L. . | 96 | 18th January 1909. | 30 years. |
| Do. . | (230) Messrs. Lalbihari Naraindas and Ramcharan Shunkar Lall of Kamptee. | Do. . . | P. L. . | 594 | 5th January 1909. | 1 year. |
| Do. . | (231) Mr. A. C. Bleehynden. | Do. . . | P. L. . | 1,078 | 15th January 1909. | Do. |
| Do. . | (232) Lala B. Sitaram . | Do. . . | P. L. . | 323 | 31st March 1909. | Do. |
| Do. . | (233) Mr. Byramji Pestonji. | All minerals . | E. L. . | 887 | 31st January 1909. | Do. |
| Do. . | (234) Babu Kripa Shanker. | Manganese . . | P. L. . | 188 | Do. . | Do. |
| Do. . | (235) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 187 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (236) Mr. C. Velu Ayah . | Manganese . | P. L. | 98 | 29th March 1909. | 1 year. |
| Do. . | (237) Nagpur Manganese Mining Syndicate, Ltd. | All minerals | E. L. | 766 | 26th March 1909. | Do |
| Do. | (238) Mr. Byramji Pestonji. | Manganese . | P. L. | 212 | 13th May 1909. | Do. |
| Do. | (239) Babu Kripa Shanker. | Do. | P. L. | 145 | 24th June 1909. | Do. |
| Do. . | (240) Mr. Byramji Pestonji. | Do. | P. L. | 70 | 13th May 1909. | Do. |
| Do. . | (241) Do. do. | All minerals | E. L. | 3,157 | 24th April 1909. | Do. |
| Do. . | (242) Babu Kripa Shankar. | Do. | E. L. | 346 | 14th June 1909. | Do. |
| Do. . | (243) Messrs. Ratanchand Kesrichand Chullany & Sons. | Manganese . | P. L. | 220 | Do. | Do. |
| Do. . | (244) Nagpur Manganese Mining Syndicate, Ltd. | All minerals | E. L. | 106 | 20th May 1909. | Do. |
| Do. . | (245) The Central India Mining Co., Ltd. | Manganese . | P. L. | 115 | 30th June 1909. | Do. |
| Do. . | (246) Babu Kripa Shankar. | All minerals | E. L. | 518 | 14th June 1909. | Do. |
| Do. . | (247) Mr. Byramji Pestonji. | Do. | E. L. | 272 | 15th May 1909. | Do. |
| Do. . | (248) Mr. S. O. Holmes . | Manganese . | P. L. | 334 | 10th August 1909. | Do. |
| Do. . | (249) Mr. M. M. Mullna, Pleader, Balaghat. | Do. | P. L. | 789 | 20th August 1909. | Do. |
| Do. . | (250) Mr. C. Velu Ayah . | Do. | P. L. | 45 | 23rd August 1909. | Do. |
| Do. . | (251) Mr. Byramji Pestonji of Raipur. | Do. | P. L. | 121 | 9th September 1909. | Do. |
| Do. . | (252) Rai Saheb Mathura Prasad and Motilal of Chhindwara. | Do. | M. L. | 13 | 1st July 1909 | 30 years. |
| Do. . | (253) Mr. Hiralal Sukhul | Do. | M. L. | 16 | Do. | Do. |
| Do. . | (254) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth of Kamptee. | Do. | P. L. | 80 | 8th August 1909. | 1 year. |
| Do. . | (255) Babu Kripa Shankar. | Do. | P. L. | 347 | 29th September 1909. | Do. |
| Do. . | (256) Mr. Hiralal Sukhul | Do. | M. L. | 16 | 9th September 1909. | 30 years. |

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (257) Messrs. Ratanchand Kesrichand Chullany & Sons. | All minerals . | E. L. . | 148 | 11th September 1909. | 1 year. |
| Do. . | (258) The Bombay Prospecting and Mining Syndicate. | Do. . | E. L. . | 544 | 18th November 1909. | Do. |
| Do. . | (259) Mr. Byramji Pestonji. | Do. . . | E. L. . | 6,219 | 26th November 1909. | Do. |
| Do. . | (260) Messrs. Schroder, Smidt & Co. | Manganese . . | P. L. . | 52 | 29th October 1909. | Do. |
| Do. . | (261) Do. do. . | Do. . . | P. L. . | 1,035 | Do. . | Do. |
| Do. . | (262) Do. do. . | Do. . . | P. L. . | 530 | 8th October 1909. | Do. |
| Do. . | (263) Messrs. Kassambhoy, Ramji & Co. | Mica . . . | P. L. . | 285 | 2nd October 1909. | Do. |
| Do. . | (264) Nagpur Manganese Mining Syndicate, Ltd. | All minerals . | E. L. . | 94 | 16th November 1909. | Do. |
| Betul . . | (265) Rai Bahadur Ballabhdas and Kuwar Jiwandas. | Coal, copper, manganese, gold, silver and mineral oil. | P. L. . | 8,890 | 10th February 1909. | Do. |
| Do. . . | (266) Mr. Hanumantrao, Kamptee. | Graphite . . | P. L. . | 522 | Do. . | Do. |
| Do. . . | (267) Mr. Byramji Pestonji. | All minerals . | E. L. . | 342 | 5th June 1909. | Do. |
| Do. . . | (268) Do. do. . | Do. . | E. L. . | 324 | Do. . | Do. |
| Do. . . | (269) Mr. P. E. Cameron | Coal . . . | P. L. . | 1,874 | 11th September 1909. | Do. |
| Do. . . | (270) Mr. R. K. Kanga . | Do. . . . | P. L. . | 2,182 | 26th July 1909. | Do. |
| Do. . . | (271) Mr. Tricumdas Cooverji. | Do. . . . | P. L. . | 2,872 | 25th November 1909. | Do. |
| Do. . . | (272) Do. do. . | Do. . . . | P. L. . | 1,110 | Do. . | Do. |
| Do. . . | (273) Mr. Khimji Cooverji of Bombay. | Do. . . . | P. L. . | 1,363 | 5th October 1909. | Do. |
| Do. . . | (274) Seth Lakshmichand. | Manganese . . | P. L. . | 148 | 25th October 1909. | Do. |
| Do. . . | (275) Mr. E. Nagannah Naidu. | Graphite . . | P. L. . | 88 | 10th November 1909. | Do. |
| Bhandara . | (276) Babu Madhulal Dugar, Calcutta. | Manganese . | P. L. . | 262 | 13th March 1909. | Do. |
| Do. . | (277) Messrs. Lalbihari Naraindas and Ramcharan Shunker Lall of Kamptee. | Do. . . | P. L. . | 847 | 2nd March 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (278) Mr. R. H. Richardson, Kamptee. | Manganese . . | M. L. . | 50 | 12th December 1908. | 30 years. |
| Do. . | (279) Central India Mining Co., Ltd., Kamptee. | Do. . . | M. L. . | 207 | 10th December 1908. | Do. |
| Do. . | (280) Diwan Bahadur Kasturchand Daga. | Do. . . | M. L. . | 176 | 4th February 1909. | Do. |
| Do. . | (281) Mr. S. S. Wazalwar | Do. . . | P. L. . | 140 | 9th February 1909. | 1 year. |
| Do. . | (282) Messrs. Ramprasad and Laxminarayan. | Do. . . | P. L. . | 223 | 5th March 1909. | Do. |
| Do. . | (283) Mr. Rambilas Murlidhar. | Do. . . | M. L. . | 143 | 16th January 1909. | 30 years. |
| Do. . | (284) Messrs. Jessop & Co., Calcutta. | Do. . . | P. L. . | 114 | 9th January 1909. | 1 year. |
| Do. . | (285) Do. do. | Do. . . | P. L. . | 249 | 14th February 1909. | Do. |
| Do. . | (286) Mr. Hiralal Sukhlal | Do. . . | P. L. . | 362 | 9th January 1909. | Do. |
| Do. . | (287) Mr. T. B. Kantharia. | Do. . . | P. L. . | 60 | Do. . | Do. |
| Do. . | (288) Do. do. . | Do. . . | P. L. . | 96 | 8th February 1909. | Do. |
| Do. . | (289) Mr. Byramji Pestonji. | All minerals . | E. L. . | 2,442 | 20th February 1909. | Do. |
| Do. . | (290) Central India Mining Co., Ltd. | Manganese . . | M. L. . | 507 | 10th December 1908. | 30 years. |
| Do. . | (291) Do. do. . | Do. . . | M. L. . | 122 | Do. . | Do. |
| Do. . | (292) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth, Kamptee. | Do. . . | P. L. . | 273 | 17th February 1909. | 1 year. |
| Do. . | (293) Mr. Vinayak Rao Vaidya. | Do. . . | P. L. . | 198 | 26th March 1909. | Do. |
| Do. . | (294) Mr. Byramji Pestonji. | Do. . . | M. L. . | 47 | 2nd March 1909. | 30 years. |
| Do. . | (295) Messrs. P. S. Kotwal and S. R. Naidu. | Do. . . | P. L. . | 85 | 8th February 1909. | 1 year. |
| Do. . | (296) Mr. Bansilal Kalar | Do. . . | P. L. . | 205 | 27th February 1909. | Do. |
| Do. . | (297) Do. do. . | Do. . . | P. L. . | 64 | Do. . | Do. |
| Do. . | (298) Seth Jagannath . | Do. . . | P. L. . | 57 | 26th March 1909. | Do. |
| Do. . | (299) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. . . | P. L. . | 354 | 16th March 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (300) Lala Bansilal Kalar | Manganese . . | P. L. . | 299 | 27th February 1909. | 1 year. |
| Do. . | (301) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 232 | 30th March 1909. | Do. |
| Do. . | (302) Do. do. . | All minerals . | E. L. . | 35 | Do. . | Do. |
| Do. . | (303) Mr. Byramji Pestonji. | Do. . . | E. L. . | 505 | 6th March 1909. | Do. |
| Do. . | (304) Do. do. . | Do. . . | E. L. . | 4,743 | 31st March 1909. | Do. |
| Do. . | (305) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | E. L. . | 104 | 12th March 1909. | Do. |
| Do. . | (306) Do. do. . | Do. . . | E. L. . | 159 | 30th March 1909. | Do. |
| Do. . | (307) Do. do. . | Do. . . | E. L. . | 74 | Do. . | Do. |
| Do. . | (308) Mr. H. Verma of Chhindwara. | Manganese . . | P. L. . | 183 | 7th May 1909 | Do. |
| Do. . | (309) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. . . | P. L. . | 97 | 21st May 1909. | Do. |
| Do. . | (310) Mr. H. Verma of Chhindwara. | Do. . . | P. L. . | 18 | 15th May 1909. | Do. |
| Do. . | (311) Mr. T. B. Kantharia. | Do. . . | P. L. . | 55 | 21st April 1909. | Do. |
| Do. . | (312) Mr. D. Laxminarayan. | Do. . . | M. L. . | 61 | 24th March 1909. | 30 years |
| Do. . | (313) Mr. R. K. Kanga . | Manganese, tin, copper, wolfram, lead, graphite and silver. | P. L. . | 1,300 | 1st June 1909 | 1 year. |
| Do . | (314) Mr. R. H. Richardson. | Manganese . . | M. L. . | 23 | 9th March 1909. | 30 years |
| Do. . | (315) Mr. Rambilas Murlidhar. | Do. . . | P. L. . | 274 | 8th May 1909. | 1 year. |
| Do. . | (316) Messrs. Balibhadra and Mohanlal. | Do. . . | P. L. . | 288 | 25th April 1909. | Do. |
| Do. . | (317) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. . . | P. L. . | 150 | 16th April 1909. | Do. |
| Do. . | (318) Messrs. Brahma Dutta Baijnath of Tumsar. | Do. . . | P. L. . | 97 | 14th June 1909. | Do. |
| Do. . | (319) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. . . | P. L. . | 631 | 20th June 1909. | Do. |
| Do. . | (320) Mr. P. Balkrishna Naidu. | Do. . . | P. L. . | 108 | 31st May 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara | (321) Diwan Bahadur Kasturchand Daga. | Manganese | P. L. | 128 | 21st May 1909. | 1 year. |
| Do. | (322) Nagpur Manganese Mining Syndicate, Ltd. | Do. | P. L. | 104 | 26th May 1909. | Do. |
| Do. | (323) Messrs. B. B. B. Fouzdar Bros. | Do. | P. L. | 257 | 4th June 1909. | Do. |
| Do. | (324) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. | P. L. | 78 | Do. | Do. |
| Do. | (325) Mr. E. C. Dungore | Do. | P. L. | 171 | 14th April 1909. | Do. |
| Do. | (326) Nagpur Manganese Mining Syndicate, Ltd. | Do. | P. L. | 15 | 26th May 1909. | Do. |
| Do. | (327) Do. do. | Do. | P. L. | 35 | Do. | Do. |
| Do. | (328) Mr. Byramji Pestonji. | Do. | P. L. | 505 | 1st May 1909 | Do. |
| Do. | (329) Do. do. | Do. | P. L. | 193 | 15th June 1909. | Do. |
| Do. | (330) Nagpur Manganese Mining Syndicate, Ltd. | All minerals | E. L. | 97 | 15th April 1909. | Do. |
| Do. | (331) Mr. E. C. Dungore | Manganese | P. L. | 4 | 21st May 1909. | Do. |
| Do. | (332) Mr. Byramji Pestonji. | All minerals | E. L. | 7 | 1st May 1909 | Do. |
| Do. | (333) Do. do | Manganese | P. L. | 93 | 31st May 1909. | Do. |
| Do. | (334) Nagpur Manganese Mining Syndicate, Ltd. | Do. | P. L. | 17 | 26th May 1909. | Do. |
| Do. | (335) Mr. P. Balkrishna Naidu. | Do. | P. L. | 291 | 31st May 1909. | Do. |
| Do. | (336) Mr. Kashinath Ramchandra Pandey. | Do. | P. L. | 27 | 20th May 1909. | Do. |
| Do. | (337) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. | P. L. | 615 | 12th July 1909. | Do. |
| Do. | (338) Messrs. Lall Behari Naraindass and Ramcharan Shunkar Lall. | Do. | P. L. | 197 | 10th August 1909. | Do. |
| Do. | (339) Dewan Bahadur Kusturchand Daga. | Do. | M. L. | 320 | 11th August 1909. | 30 years. |
| Do. | (340) Messrs. Lall Behari Naraindass. | Do. | M. L. | 35 | 26th July 1909. | 5 years. |
| Do. | (341) Mr. D. Laxminarayan. | Do. | M. L. | 21 | 29th July 1909. | 30 years. |
| Do. | (342) Mr. Gowardhandas | Do. | P. L. | 55 | 5th August 1909. | 1 year. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (343) Seth Gowardhandas | Manganese . . | P. L. . | 100 | 2nd August 1909. | 1 year. |
| Do. . | (344) Messrs. Kassambhoy, Gopaldass and Co. | Do. . . | P. L. . | 81 | Do. . | Do. |
| Do. . | (345) Do. do. . | Do. . . | P. L. . | 322 | 27th July 1909. | Do. |
| Do. . | (346) Messrs. Shamji Madhoji. | Do. . . | P. L. . | 100 | 16th September 1909. | Do. |
| Do. . | (347) Messrs. Schroder, Smidt & Co. | Do. . . | P. L. . | 59 | 6th August 1909. | Do. |
| Do. . | (348) Do. do. . | Do. . . | P. L. . | 146 | 7th August 1909. | Do. |
| Do. . | (349) Do. do. . | Do. . . | P. L. . | 35 | Do. . | Do. |
| Do. . | (350) Dewan Bahadur Kasturchand Daga. | Do. . . | P. L. . | 39 | 10th August 1909. | Do. |
| Do. . | (351) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth. | Do. . . | P. L. . | 151 | 1st September 1909. | Do. |
| Do. . | (352) Do. do. . | Do. . . | P. L. . | 494 | 2nd August 1909. | Do. |
| Do. . | (353) Do. do . | Do. . . | P. L. . | 263 | 27th July 1909. | Do. |
| Do. . | (354) Do. do. . | Do. . . | P. L. . | 57 | 6th August 1909. | Do. |
| Do. . | (355) Central India Mining Co., Ltd. | Do. . . | M. L. . | 2 | 20th September 1909. | 30 years. |
| Do. . | (356) Messrs. Bramhadutt and Baijnath. | Do. . . | P. L. . | 337 | 22nd August 1909. | 1 year. |
| Do. . | (357) Seth Pokarmal Beharilal. | Do. . . | P. L. . | 31 | 23rd August 1909. | Do. |
| Do. . | (358) Mr. T. Cooverji Bhoja. | Do. . . | P. L. . | 2,000 | 8th December 1909. | Do. |
| Do. . | (359) Messrs. Rampershad and Laxminarayan. | Do. . . | P. L. . | 446 | 22nd December 1909. | Do. |
| Do. . | (360) Messrs. Radhakisan and Brothers. | Do. . . | P. L. . | 7 | 21st October 1909. | Do. |
| Do. . | (361) Mr. D. Gangadhar Rao. | Do. . . | P. L. . | 52 | 24th November 1909. | Do. |
| Do. . | (362) Rai Sahib Mathura Prasad and Motilal. | Do. . . | M. L. . | 4 | 30th September 1909. | 30 years. |
| Do. . | (363) Mr. P. Balkrishna Naidu. | Do. . . | M. L. . | 92 | 2nd November 1909. | Do. |
| Do. . | (364) Mr. E. Nagannah Naidu. | Do. . | M. L. . | 10 | 11th November 1909. | 5 years. |

E. L. denotes Exploring License; P. L., Prospecting License: and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (365) Dewan Bahadur Kasturchand Daga. | Manganese . . | P. L. . | 88 | 2nd August 1909. | 1 year. |
| Do. . | (366) Seth Jagannath of Tumsar. | Do. . . | M. L. . | 41 | 26th November 1909. | 30 years. |
| Do. . | (367) Mr. Rambilas Murlidhar. | Do. . . | P. L. . | 20 | 11th October 1909. | 1 year. |
| Do. . | (368) Messrs. Sitharam Nathu and Govind Sitharam of Lakhni. | Do. . . | P. L. . | 32 | 21st October 1909. | Do. |
| Do. . | (369) Mr. E. C. Dungore | Do. . . | P. L. . | 62 | 22nd December 1909. | Do. |
| Do. . | (370) Mr. Rambilas Murlidhar. | Do. . . | P. L. . | 185 | 17th December 1909. | Do. |
| Do. . | (371) Messrs. Sitharam Nathu and Govind Sitharam. | Do. . . | P. L. . | 68 | Do. . | Do. |
| Do. . | (372) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 248 | 16th November 1909. | Do. |
| Chanda . | (373) Mr. Byramji Pestonji. | All minerals . | E. L. . | Entire village | 15th March 1909. | Do. |
| Do. . | (374) Do. do. . | Do. . | E. L. . | Do. | Do. . | Do. |
| Do. . | (375) Messrs. Umarali Brothers. | Do. . | E. L. . | 5,345 | 5th July 1909. | Do. |
| Do. . | (376) Messrs. H. Verma and Kanhayalal. | Coal . . . | P. L. . | 1,363 | 2nd December 1909. | Do. |
| Do. . | (377) Do. do. . | Do. . . | P. L. . | 2,976 | Do. . | Do. |
| Do. . | (378) Do. do. . | All minerals . | E. L. . | 6,663 | 29th November 1909. | Do. |
| Do. . | (379) Do. do. . | Do. . | E. L. . | 8,758 | Do. . | Do. |
| Chhindwara . | (380) Indian Manganese Company, Ltd. | Manganese . . | M. L. . | 24 | 6th January 1909. | 30 years. |
| Do. . | (381) Messrs. Macbeth Brothers & Co. | Coal . . . | P. L. . | 992 | 22nd January 1909. | 1 year. |
| Do. . | (382) R. S. Mathura Parsad and Motilal. | Manganese . . | M. L. . | 17 | 12th March 1909. | 30 years. |
| Do. . | (383) Mr. W. Stalkartt . | Do. . . | P. L. . | 324 | 27th April 1909. | 1 year. |
| Do. . | (384) Messrs. Abdur Rahim Khan and Khimji Cooverji. | Coal . . . | P. L. . | 4,889 | 14th June 1909. | Do. |
| Do. . | (385) Mr. D. N. Mitra . | Manganese . . | P. L. . | 105 | 22nd May 1909. | Do. |
| Do. . | (386) Mr. J. C. Stalkartt | Do. . . | P. L. . | 90 | 9th June 1909. | Do. |

E. L. denotes Exploring License: P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Chhindwara . | (387) Rai Saheb Mathura Prasad Motilal and Co. | All minerals . . | E. L. . | 5,506 | 12th June 1909. | 1 year. |
| Do. . | (388) Indian Manganese Co., Ltd. | Manganese . . | P. L. . | 58 | 21st July 1909. | Do. |
| Do. . | (389) Messrs. P. S. Kotwal and S. R. Naidu. | Do. . . | P. L. . | 96 | 4th November 1909. | Do. |
| Do. . | (390) Messrs. Baiya Lall and Narur Patel. | Do. . . | P. L. . | 101 | 21st October 1909. | Do. |
| Do. . | (391) Mr. A. C. Blechynden of Jubbulpore. | Do. . . | P. L. . | 20 | 15th December 1909. | Do. |
| Do. . | (392) Do. do. . | Do. . . | P. L. . | 26 | Do. . | Do. |
| Do. . | (393) Mr. Govind Rao Baji Rao Deshmukh of Kelod. | Do. . . | P. L. . | 79 | 14th December 1909. | Do. |
| Do. . | (394) The Indian Manganese Co. | All minerals . | E. L. . | 1,557 | 11th November 1909. | Do. |
| Drug . . | (395) Lala Indrashah, Zamindar, Ambagarh Chowki. | Lead and quicksilver. | P. L. . | 167 | 18th May 1909. | Do. |
| Jubbulpore . | (396) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese . . | P. L. . | 498 | 1st March 1909. | Do. |
| Do. . | (397) Do. do. . | Do. . . | P. L. . | 102 | 22nd March 1909. | Do. |
| Do. . | (398) Do. do. . | Do. . . | P. L. . | 40 | 15th June 1909. | Do. |
| Do. . | (399) The Bombay Prospecting and Mining Syndicate. | Soapstone, steatite, and talc. | P. L. . | 647 | 21st April 1909. | Do. |
| Do. . | (400) Mr. D. W. A. MacDonald of Murwara. | All minerals . | E. L. . | 40 | 24th April 1909. | Do. |
| Do. . | (401) Do. do. . | Do. . | E. L. . | 567 | Do. . | Do. |
| Do. . | (402) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese . . | P. L. . | 46 | 5th July 1909. | Do. |
| Do. . | (403) Do. do. . | Do. . . | P. L. . | 242 | Do. . | Do. |
| Do. . | (404) Bombay Prospecting and Mining Syndicate. | Bauxite . . | P. L. . | 375 | 26th July 1909. | Do. |
| Do. . | (405) Mr. M. Gupta, Barrister-at-Law, Hoshangabad. | All minerals . | E. L. . | 684 | 23rd July 1909. | Do. |
| Do. . | (406) Mr. R. K. Kanga . | Manganese and Iron. | P. L. . | 371 | 30th September 1909. | Do. |
| Do. . | (407) Do. do. . | Do. . | P. L. . | 292 | 20th August 1909. | Do. |

E. L. denotes Exploring License ; P. L. Prospecting License ; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Jubbulpore . | (408) Messrs. C. MacDonald & Co. | All minerals . | E. L. . | 633 | 15th July 1909. | 1 year. |
| Do. . | (409) Do. do. . | Iron . . . | P. L. . | 633 | 31st August 1909. | Do. |
| Do. . | (410) Mr. M. Gupta, Barrister-at-Law, Hoshangabad. | Soapstone, stealite and talc. | P. L. . | 216 | 20th September 1909. | Do. |
| Do. . | (411) Mr. P. C. Dutt, Barrister-at-Law, Jubbulpore. | All minerals . | E. L. . | 2,586 | 30th July 1909. | Do. |
| Do. . | (412) Bombay Prospecting and Mining Syndicate. | Do. . | E. L. . | 1,697 | 23rd July 1909. | Do. |
| Do. . | (413) Messrs. Burn and Co. and P. C. Dutt. | Gold, silver, copper and lead. | M. L. . | 49 | 5th October 1909. | 30 years. |
| Do. . | (414) Messrs. H. F. Cook & Sons, Murwara. | Bauxite . . | P. L. . | 288 | 16th December 1909. | 1 year. |
| Do. . | (415) Mr. C. Velu Ayah . | Manganese . . | P. L. . | 207 | 29th October 1909. | Do. |
| Do. . | (416) Seth Timorasji Cowasji. | Coal . . . | P. L. . | 86 | 8th November 1909. | Do. |
| Nagpur . | (417) Messrs. B. B. B. Fouzdar Brothers. | Manganese and mica. | P. L. . | 439 | 13th March 1909. | Do. |
| Do. . | (418) Messrs. Jessop & Co. | Manganese . . | M. L. . | 90 | 12th March 1909. | 30 years. |
| Do. . | (419) Mr. Venkat Rao Naik. | Do. . . | P. L. . | 18 | 2nd March 1909. | 1 year. |
| Do. . | (420) Lala B. Sitaram, Kamptee. | Do. . . | P. L. . | 279 | 16th January 1909. | Do. |
| Do. . | (421) Messrs. B. B. B. Fouzdar and Brothers. | Manganese and coal. | P. L. . | 26 | 13th March 1909. | Do. |
| Do. . | (422) Hon'ble Mr. G. M. Chitnavis of Nagpur. | Manganese . . | P. L. . | 278 | 13th February 1909. | Do. |
| Do. . | (423) Mr. S. O. Holmes . | Manganese, iron, copper, tin, bismuth, wolfram and molybdenum. | P. L. . | 65 | 7th January 1909. | Do. |
| Do. . | (424) Mr. Byramji Pestonji. | Manganese . . | P. L. . | 301 | 20th March 1909. | Do. |
| Do. | (425) Hon'ble Mr. G. M. Chitnavis. | Do. . . | P. L. . | 50 | 29th March 1909. | Do. |
| Do. . | (426) Central Provinces Prospecting Syndicate, Ltd. | Do. . . | M. L. . | 37 | 22nd January 1909. | 30 years. |
| Do. . | (427) Mr. S. O. Holmes . | Manganese, iron, tin, copper, wolfram and bismuth. | P. L. . | 513 | 7th January 1909. | 1 year. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (428) Mr. S. G. Holmes. | Manganese, iron, tin, copper, wolfram and bismuth. | P. L. . | 287 | 7th January 1909. | 1 year. |
| Do. . | (429) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese . . | P. L. . | 165 | 31st March 1909. | Do. |
| Do. . | (430) Mr. Byramji Pestonji. | Do. . . | P. L. . | 599 | Do. . | Do. |
| Do. . | (431) Mr. Darashah Mancherji of Kamptee. | Do. . . | P. L. . | 102 | 8th February 1909. | Do. |
| Do. . | (432) Mr. Venkat Rao Naik. | Do. . . | P. L. . | 1,084 | 2nd March 1909. | Do. |
| Do. . | (433) Messrs. Martin & Co. | Manganese, iron, tin, bismuth and molybdenum. | P. L. . | 363 | 21st January 1909. | Do. |
| Do. . | (434) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese . . | P. L. . | 210 | 31st January 1909. | Do. |
| Do. . | (435) Mr. Herchandial Sitaram. | Do. . . | P. L. . | 85 | 7th January 1909. | Do. |
| Do. . | (436) Mr. Byramji Pestonji. | Do. . . | P. L. . | 70 | 23rd March 1909. | Do. |
| Do. . | (437) Messrs. Ramprasad and Laxminarayan. | Do. . . | P. L. . | 125 | 7th January 1909. | Do. |
| Do. . | (438) Indian Manganese Co., Ltd. | Do. . . | P. L. . | 49 | 21st January 1909. | Do. |
| Do. . | (439) Do. do. . | Do. . . | P. L. . | 18 | Do. . | Do. |
| Do. . | (440) Mr. G. M. Prichard | All minerals . | E. L. . | 853 | 27th January 1909. | Do. |
| Do. . | (441) Do. do. . | Do. . | E. L. . | 70 | Do. . | Do. |
| Do. . | (442) Mr. G. M. Chitnavis | Manganese. . | P. L. . | 306 | 29th March 1909. | Do. |
| Do. . | (443) Central India Mining Co., Ltd., Kamptee. | Do. . . | P. L. . | 235 | 8th February 1909. | Do. |
| Do. . | (444) Do. do. . | Do. . . | P. L. . | 348 | Do. . | Do. |
| Do. . | (445) Messrs. Martin & Co. | All minerals . | E. L. . | 720 | 21st January 1909. | Do. |
| Do. . | (446) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese, iron, bismuth, wolfram and molybdenum. | P. L. . | 153 | 27th January 1909. | Do. |
| Do. . | (447) Mr. Byramji Pestonji. | All minerals . | E. L. . | 213 | 13th February 1909. | Do. |
| Do. . | (448) Do. do. . | Do. . | E. L. . | 2,758 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (449) Mr. S. O. Holmes . | Manganese, wolfram, iron, bismuth, tin, copper and molybdenum. | P. L. . | 299 | 23rd March 1909. | 1 year. |
| Do. . | (450) Mr. P. Balkrishna Naidu. | Manganese . . | P. L. . | 102 | 2nd March 1909. | Do. |
| Do. . | (451) Messrs. P. S. Kotwal and S. R. Naidu. | Do. . . | P. L. . | 49 | 13th May 1909. | Do. |
| Do. . | (452) Nagpur Manganese Mining Syndicate. | Do. . . | P. L. . | 46 | 4th March 1909. | Do. |
| Do. . | (453) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 135 | Do. . | Do. |
| Do. . | (454) Mr. E. C. Dungore . | Do. . . | P. L. . | 13 | 27th January 1909. | Do. |
| Do. . | (455) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 85 | 16th February 1909. | Do. |
| Do. . | (456) Mr. Byramji Pestonji. | Galena . . | P. L. . | 265 | 29th March 1909. | Do. |
| Do. . | (457) Nagpur Manganese Mining Syndicate, Ltd. | Manganese . . | P. L. . | 45 | 25th March 1909. | Do. |
| Do. . | (458) Do. do. . | All minerals . | E. L. . | 35 | 21st January 1909. | Do. |
| Do. . | (459) Do. do. . | Do. . | E. L. . | 115 | Do. . | Do. |
| Do. . | (460) Do. do. . | Do. . | E. L. . | 247 | Do. . | Do. |
| Do. . | (461) Do. do. . | Do. . | E. L. . | 116 | Do. . | Do. |
| Do. . | (462) Do. do. . | Do. . | E. L. . | 118 | 13th March 1909. | Do. |
| Do. . | (463) Do. do. . | Do. . | E. L. . | 0·29 | 8th February 1909. | Do. |
| Do. . | (464) Do. do. . | Do. . | E. L. . | 101 | 21st January 1909. | Do. |
| Do. . | (465) Do. do. . | Do. . | E. L. . | 49 | 8th February 1909. | Do. |
| Do. . | (466) Do. do. . | Do. . | E. L. . | 55 | 8th February 1909. | Do. |
| Do. . | (467) Mr. Byramji Pestonji. | Do. . | E. L. . | 239 | 2nd March 1909. | Do. |
| Do. . | (468) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 148 | 8th February 1909. | Do. |
| Do. . | (469) Mr. Byramji Pestonji. | Do. . | E. L. . | 1,407 | 29th March 1909. | Do. |
| Do. . | (470) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 404 | 13th March 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur | (471) Nagpur Manganese Mining Syndicate, Ltd. | All minerals | E. L. | 45 | 25th February 1909. | 1 year. |
| Do. | (472) Do. do. | Do. | E. L. | 106 | 13th March 1909. | Do. |
| Do. | (473) Do. do. | Do. | E. L. | 41 | Do. | Do. |
| Do. | (474) Do. do. | Do. | E. L. | 82 | Do. | Do. |
| Do. | (475) Mr. Byramji Pestonji. | Do. | E. L. | 250 | 29th March 1909. | Do. |
| Do. | (476) Do. do. | Do. | E. L. | 339 | 2nd March 1909. | Do. |
| Do. | (477) Do. do. | Do. | E. L. | 375 | 29th March 1909. | Do. |
| Do. | (478) Messrs. Umarali Brothers. | Lead | P. L. | 52 | 4th March 1909. | Do. |
| Do. | (479) Nagpur Manganese Mining Syndicate, Ltd. | All minerals | E. L. | 58 | 25th March 1909. | Do. |
| Do. | (480) The Central Provinces Prospecting Syndicate, Ltd. | Manganese | M. L. | 5 | 12th April 1909. | 30 years. |
| Do. | (481) Mr. D. Laxminarayan. | Do. | P. L. | 184 | 28th April 1909. | 1 year. |
| Do. | (482) The Central India Mining Co., Ltd. | Do. | M. L. | 8 | 19th April 1909. | 30 years. |
| Do. | (483) Messrs. Kassambhoy Ramjee & Co. | Do. | P. L. | 8 | 11th May 1909 | 1 year. |
| Do. | (484) Lala Mohanlal Kalar. | Do. | P. L. | 375 | 22nd June 1909. | Do. |
| Do. | (485) Messrs. Kassambhoy Ramjee & Co. | Do. | P. L. | 125 | 11th May 1909 | Do. |
| Do. | (486) Do. do. | Do. | P. L. | 55 | Do. | Do. |
| Do. | (487) Mr. M. B. Dadabhoy | Do. | P. L. | 85 | Do. | Do. |
| Do. | (488) Messrs. P. S. Kotwal and S. R. Naidu. | Do. | P. L. | 924 | 22nd May 1909 | Do. |
| Do. | (489) Messrs. Kassambhoy Ramjee & Co. | Do. | P. L. | 50 | 16th June 1909. | Do. |
| Do. | (490) Messrs. Ramprasad and Laxminarayan. | Do. | P. L. | 53 | 28th April 1909. | Do. |
| Do. | (491) The Central Provinces Prospecting Syndicate, Ltd. | Do. | M. L. | 31 | 3rd April 1909. | 30 years. |
| Do. | (492) Messrs. P. S. Kotwal and S. R. Naidu. | Do. | P. L. | 210 | 31st March 1909. | 1 year. |
| Do. | (493) Mir Aslam Khan of Ramtek. | Do. | P. L. | 187 | 18th May 1909 | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (494) Mr. Byramji Pestonji. | All minerals . | E. L. . | 1,577 | 22nd June 1909. | 1 year. |
| Do. . | (495) Do. do. . | Manganese and copper. | P. L. . | 46 | 11th May 1909 | Do. |
| Do. . | (496) Do. do. . | Do. . | P. L. . | 110 | Do. . | Do. |
| Do. . | (497) Mr. T. B. Kantharia. | Manganese . . | P. L. . | 92 | 28th April 1909. | Do. |
| Do. . | (498) Mr. Hanmant Rao Yeloji Rao Mohitey. | Do. . . | P. L. . | 102 | 11th May 1909 | Do. |
| Do. . | (499) Mr. T. B. Kantharia. | Do. . . | P. L. . | 90 | 28th April 1909. | Do. |
| Do. . | (500) Mr. M. B. Dadabhoy | Do. . . | P. L. . | 11 | 11th May 1909 | Do. |
| Do. . | (501) Mr. T. B. Kantharia. | Do. . . | P. L. . | 148 | 28th April 1909. | Do. |
| Do. . | (502) The Central Provinces Prospecting Syndicate, Ltd. | Do. . . | M. L. . | 46 | 1st May 1909 | *30 years. |
| Do. . | (503) Mr. Herchand Lal Sitaram. | Do. . . | P. L. . | 205 | 17th April 1909. | 1 year. |
| Do. . | (504) Mr. Byramji Pestonji. | Do. . . | P. L. . | 76 | 11th May 1909 | Do. |
| Do. . | (505) Mr. Herchand Lal Sitaram. | Do. . . | P. L. . | 248 | 16th June 1909. | Do. |
| Do. . | (506) Mr. Byramji Pestonji. | Do. . . | P. L. . | 27 | 22nd June 1909. | Do. |
| Do. . | (507) Mr. T. B. Kantharia. | Do. . . | P. L. . | 100 | 28th April 1909. | Do. |
| Do. . | (508) Do. do. . | Do. . . | P. L. . | 100 | Do. . | Do. |
| Do. . | (509) Mr. E. C. Dungore . | Do. . . | P. L. . | 212 | 22nd June 1909. | Do. |
| Do. . | (510) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 52 | 22nd May 1909. | Do. |
| Do. . | (511) Do. do. . | Do. . . | P. L. . | 58 | Do. . | Do. |
| Do. . | (512) Do. do. . | Do. . . | P. L. . | 35 | 13th April 1909. | Do. |
| Do. . | (513) Do. do. . | Do. . . | P. L. . | 101 | 22nd June 1909. | Do. |
| Do. . | (514) Lala Balibhadra and Mohanlal. | Do. . . | P. L. . | 166 | 28th April 1909. | Do. |
| Do. . | (515) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 42 | 22nd May 1909. | Do. |
| Do. . | (516) Do. do. . | Do. . . | P. L. . | 89 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur | (517) Messrs. Umarali Brothers. | All minerals | E. L. | 396 | 17th April 1909. | 1 year. |
| Do. | (518) Do. do. | Do. | E. L. | 1,873 | Do. | Do. |
| Do. | (519) Nagpur Manganese Mining Syndicate, Ltd. | Manganese | P. L. | 41 | 22nd May 1909. | Do. |
| Do. | (520) Mr. E. G. Beckett | All minerals | E. L. | 610 | 16th June 1909. | Do. |
| Do. | (521) Do. do. | Do. | E. L. | 432 | Do. | Do. |
| Do. | (522) Do. do. | Do. | E. L. | 819 | Do. | Do. |
| Do. | (523) Do. do. | Do. | E. L. | 1,192 | Do. | Do. |
| Do. | (524) Nagpur Manganese Mining Syndicate, Ltd. | Do. | E. L. | 18 | 17th April 1909. | Do. |
| Do. | (525) Mr. Byramji Pestonji. | Do. | E. L. | 1,211 | 22nd June 1909. | Do. |
| Do. | (526) Messrs. R. K. Chullany & Sons. | Do. | E. L. | 14 | 16th May 1909 | Do. |
| Do. | (527) Messrs. Umarali Brothers. | Do. | E. L. | 1,221 | Do. | Do. |
| Do. | (528) Nagpur Manganese Mining Syndicate, Ltd. | Do. | E. L. | 62 | 17th April 1909. | Do. |
| Do. | (529) Do. do. | Do. | E. L. | 37 | Do. | Do. |
| Do. | (530) Mr. Dhawakalnal Gunpatilal. | Do. | E. L. | 83 | 11th May 1909 | Do. |
| Do. | (531) Do. do. | Do. | E. L. | 31 | 25th May 1909 | Do. |
| Do. | (532) Nagpur Manganese Mining Syndicate, Ltd. | Do. | E. L. | 1,225 | 12th June 1909. | Do. |
| Do. | (533) Do. do. | Do. | E. L. | 149 | Do. | Do. |
| Do. | (534) Do. do. | Do. | E. L. | 575 | 22nd June 1909. | Do. |
| Do. | (535) Messrs. Kassambhoy Ramjee & Co. | Do. | E. L. | 776 | 29th June 1909. | Do. |
| Do. | (536) Bansilal Abeerchand Mining Syndicate (Mr. T. Cooverji Bhoja of Calcutta). | Manganese | M. L. | 200 | 3rd September 1909. | 30 years. |
| Do. | (537) Mr. Madhulal Doogar of Calcutta. | Do. | P. L. | 196 | 3rd July 1909. | 1 year. |
| Do. | (538) Messrs. Jessop and Company of Calcutta. | Do. | P. L. | 1,877 | 10th July 1909. | Do. |
| Do. | (539) The Central India Mining Co., Ltd. | Do. | M. L. | 63 | 24th June 1909. | 30 years. |
| Do. | (540) The Central Provinces Prospecting Syndicate, Ltd. | Do. | M. L. | 42 | 22nd June 1909. | Do. |

E. L. denotes Exploring License: P. L., Prospecting License: and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur | (541) Satak Manganese Co. | Manganese | M. L. | 64 | 16th August 1909. | 30 years. |
| Do. | (542) Hon'ble Mr. M. B. Dadabhoy. | Do. | P. L. | 765 | 20th August 1909. | 1 year. |
| Do. | (543) Do. do. | Do. | P. L. | 128 | Do. | Do. |
| Do. | (544) Messrs. Kassambhoy Ramjee & Co. | Do. | P. L. | 28 | 29th September 1909. | Do. |
| Do. | (545) The Indian Manganese Mining Company, Ltd. | Do. | P. L. | 72 | 28th August 1909. | Do. |
| Do. | (546) Mr. D. Laxminarayan of Kamptee. | Do. | M. L. | 76 | 21st June 1909. | 30 years. |
| Do. | (547) Mr. Shamji Madhoji | Copper | P. L. | 53 | 27th September 1909. | 1 year. |
| Do. | (548) Mr. Nowroji Pellonji of Bombay. | Manganese, galena, molybdenum and lead. | P. L. | 1,316 | Do. | Do. |
| Do. | (549) Mr. Byramji Pestonji of Raipur. | Manganese, mica, bauxite, galena and asbestos. | P. L. | 53 | 20th August 1909. | Do. |
| Do. | (550) Mr. Shamji Madhoji | Manganese | P. L. | 238 | 27th September 1909. | Do. |
| Do. | (551) Mr. D. Gungadhar Rao. | Do. | P. L. | 10 | 10th July 1909. | Do. |
| Do. | (552) Mr. Byramji Pestonji. | All minerals | E. L. | 3,825 | 20th August 1909. | Do. |
| Do. | (553) Mr. G. M. Prichard | Manganese | P. L. | 46 | 10th August 1909. | Do. |
| Do. | (554) Messrs. Ramprasad and Laxminarayan. | Manganese, wolfram, tin and copper. | P. L. | 20 | 27th September 1909. | Do. |
| Do. | (555) The Central India Mining Co., Ltd. | Manganese | M. L. | 99 | 24th June 1909. | 30 years. |
| Do. | (556) Mr. T. B. Kantharia. | Do. | P. L. | 150 | 6th August 1909. | 1 year. |
| Do. | (557) Mr. P. Balkrishna Naidu. | Do. | P. L. | 100 | Do. | Do. |
| Do. | (558) Mr. Vinayak Rao Vaidya. | Do. | P. L. | 139 | 20th August 1909. | Do. |
| Do. | (559) Mr. Byramji Pestonji. | All minerals | E. L. | 637 | 3rd July 1909 | Do. |
| Do. | (560) Messrs. Schroder, Smidt & Co. | Manganese | P. L. | 338 | 27th July 1909 | Do. |
| Do. | (561) Messrs. R. K. Chullany & Sons. | Mica | P. L. | 107 | 17th August 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (562) The Central India Mining Co., Ltd. | Wolfram . . | P. L. . | 231 | 30th September 1909. | 1 year. |
| Do. . | (563) Nagpur Manganese Mining Syndicate, Ltd. | Manganese . . | P. L. . | 58 | 27th July 1909. | Do. |
| Do. . | (564) Mr. Dhawak Malji Gunpat Lall. | Do. . . | P. L. . | 83 | 6th March 1909. | Do. |
| Do. . | (565) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 18 | 15th July 1909 | Do. |
| Do. . | (566) Messrs. Ratanchand Kesrichand Chullany & Sons. | Do. . . | P. L. . | 58 | 28th August 1909. | Do. |
| Do. . | (567) Mr. A. Hanmant Rao. | Do. . . | P. L. . | 30 | 20th August 1909. | Do. |
| Do. . | (568) Mr. P. Balkrishna Naidu. | Do. . . | P. L. . | 45 | 6th August 1909. | Do. |
| Do. . | (569) Messrs. Shawakshah Jamsetji Dubash and Bapuji Jamsetji Dubash. | All minerals . | E. L. . | 45 | 15th July 1909 | Do. |
| Do. . | (570) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 109 | Do. . | Do. |
| Do. . | (571) Mr. Byramji Pestonji. | Do. . | E. L. . | 672 | 20th August 1909. | Do. |
| Do. . | (572) Messrs. Shawakshah Jamsetji Dubash and Bapuji Jamsetji Dubash. | Do. . | E. L. . | 97 | 4th August 1909. | Do. |
| Do. . | (573) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 97 | Do. . | Do. |
| Do. . | (574) Messrs. P. S. Kotwal and S. R. Naidu. | Manganese . . | P. L. . | 112 | 17th November 1909. | Do. |
| Do. . | (575) Messrs. Radhakisan Brothers. | Do. . . | P. L. . | 28 | 9th October 1909. | Do. |
| Do. . | (576) Messrs. Schroder, Smidt & Co. | Do. . . | P. L. . | 111 | Do. . | Do. |
| Do. . | (577) Messrs. P. S. Kotwal and S. R. Naidu. | Do. . . | P. L. . | 108 | 24th November 1909. | Do. |
| Do. . | (578) Messrs. Ramprasad and Laxminarayan. | All minerals . | E. L. . | 320 | 22nd December 1909. | Do. |
| Do. . | (579) Seth Dawakmalji Ganpatlal. | Manganese . . | P. L. . | 31 | 9th October 1909. | Do. |
| Do. . | (580) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 140 | 30th October 1909. | Do. |
| Do. . | (581) Do. do. . | Do. . . | P. L. . | 581 | 10th December 1909. | Do. |
| Do. . | (582) Lala Bansilal Kalar | Do. . . | P. L. . | 74 | Do. . | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (583) Lala Bansilal Kalar | Manganese . | P. L. . | 29 | 10th December 1909. | 1 year. |
| Do. . | (584) Nagpur Manganese Mining Co., Ltd. | Do. . . | P. L. . | 31 | 17th November 1909. | Do. |
| Do. . | (585) Mr. P. Balkrishna Naidu. | Do. . . | P. L. . | 54 | 10th December 1909. | Do. |
| Do. . | (586) Messrs. Schroder, Smidt & Co. | Do. . . | P. L. . | 94 | 17th November 1909. | Do. |
| Do. . | (587) Nagpur Manganese Mining Syndicate, Ltd. | All minerals . | E. L. . | 6 | 27th July 1909. | Do. |
| Do. . | (588) Messrs. Schroder, Smidt & Co. | Manganese . . | P. L. . | 68 | 10th December 1909. | Do. |
| Do. . | (589) Nagpur Manganese Mining Syndicate, Ltd. | Do. . . | P. L. . | 190 | Do. . | Do. |
| Do. . | (590) Do. do. . | All minerals . | E. L. . | 527 | 30th October 1909. | Do. |
| Do. . | (591) Do. do. . | Do. . | E. L. . | 190 | 9th October 1909. | Do. |
| Do. . | (592) Do. do. . | Do. . | E. L. . | 168 | 17th November 1909. | Do. |
| Do. . | (593) Seth Balkrishna (on behalf of Rupchand Gaibiram). | Do. . | E. L. . | 848 | Do. | Do. |
| Do. . | (594) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 195 | 10th December 1909. | Do. |
| Do. . | (595) Do. do. . | Do. . | E. L. . | 72 | 17th November 1909. | Do. |
| Do. . | (596) Do. do. . | Do. . | E. L. . | 9 | Do. . | Do. |
| Do. . | (597) Do. do. . | Do. . | E. L. . | 92 | Do. . | Do. |
| Do. . | (598) Do. do. . | Do. . | E. L. . | 128 | 22nd December 1909. | Do. |
| Do. . | (599) Mr. Darasha Muncherji Dungaji. | Do. . | E. L. . | 184 | 24th November 1909. | Do. |
| Do. . | (600) Nagpur Manganese Mining Syndicate, Ltd. | Do. . | E. L. . | 143 | 22nd December 1909. | Do. |
| Raipur . | (601) Mr. Batu Krishna Gupta of Bilaspur. | Graphite . . | P. L. . | 1,355 | 17th February 1909. | Do. |
| Do. . | (602) Mr. R. K. Kanga . | Do. . . | P. L. . | 124 | 13th March 1909. | Do. |
| Do. . | (603) Do. do. . | All minerals . | E. L. . | 2,381 | 16th June 1909. | Do. |
| Do. . | (604) Messrs. Kassambhoy Ramjee & Co. | Lead . . . | P. L. . | 114 | 5th June 1909 | Do. |
| Do. . | (605) Do. do. . | All minerals . | E. L. . | 114 | 3rd May 1909 | Do. |

E. L. denotes Exploring License ; P. L., Prospecting License : and M. L., Mining Lease.

## CENTRAL PROVINCES—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Raipur . . | (606) Messrs. Byramji Pestonji & Co. | All minerals . | E. L. . | 2,466 | 10th June 1909. | 1 year. |
| Do. . . | (607) Do. do. . | Do. . | E. L. . | 797 | Do. . | Do. |
| Do. . . | (608) Messrs. Kassambhoy Ramjee & Co. | Do. . | E. L. . | 925 | 5th June 1909 | Do. |
| Do. . . | (609) Mr. R. K. Kanga . | Manganese, coal, iron, graphite and lead. | P. L. . | 2,381 | 25th September 1909. | Do. |
| Saugor . . | (610) Gantpat Rao Shrikande, Gopal Rao and Ramkrishna Rao Shrikande, retired E. A. C., and pleaders at Saugor. | Gold, silver, copper, coal, iron and mineral oil. | P. L. . | 368 | 10th March 1909. | Do. |
| Seoni . . | (611) Messrs. Schroder, Smidt & Co., Calcutta, per L. De Souza, Agent and Attorney, Nagpur. | Manganese . . | P. L. . | 46 | 8th September 1909. | Do. |
| Do. . . | (612) Messrs. A. C. Blechynden of Jubbulpore. | All minerals . | E. L. . | Three whole villages of Kaliruth, Karhaiya and Dungaria. | 16th August 1909. | Do. |
| Do. . . | (613) Mr. Khimji Cooverji | Iron . . . . | P. L. . | 2,292 | 18th December 1909. | Do. |
| Wardha . | (614) Rao Bahadur Rajaram Pant Dixit. | Coal . . . . | P. L. . | 2,715 | 27th April 1909. | Do. |

## EASTERN BENGAL AND ASSAM.

| | | | | | | |
|---|---|---|---|---|---|---|
| Chittagong . | (615) Messrs. Turner, Morrison & Co., Calcutta. | Coal, oil, iron, etc. | P. L. (renewal) | 2,675 | 10th July 1909. | 1 year. |
| Lakhimpur . | (616) The Assam Railways and Trading Co., Ltd., of Dibrugarh. | Coal, iron, etc. . | P. L. . | 22,400 | 15th January 1909. | Do. |
| Do. . | (617) Babu Sew Narain Beria of Dibrugarh. | Coal . . . | P. L. (renewal) | 9,516·80 | 1st April 1909 | Do. |

## MADRAS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Bellary . . | (618) South Indian Mining Syndicate. | Manganese . . | M. L. . | 1,591·29 | 18th May 1909 | 30 years. |
| Do. . | (619) S. Craushaw . | All minerals . | E. L. . | The bed of the Tungabadra running through the district. | 9th August 1909. | 1 year. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## MADRAS—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term |
|---|---|---|---|---|---|---|
| Coimbatore . | (620) T. R. Venkataramana Aiyar. | Mica and other minerals. | E. L. . | All Government waste lands, including reserved forests. | 26th April 1909. | 1 year. |
| Do. . | (621) C. V. Narasian . | Corundum, asbestos, gypsum, manganese, crystals and precious stones. | P. L. . | 5,445·00 | Do. . | Do |
| Do. . | (622) Do. do. . | Mica . . | P. L. . | 211·92 | Do. . | Do. |
| Cuddapah . | (623) Beardsell & Co. . | Not given . . | E. L. . | Not given . | February 1909 | Do. |
| Do. . | (624) L. E. Kerwan . | Galena . . | P. L. . | 576·88 | 25th July 1909. | Do. |
| Do. . | (625) W. R. C. Beaden . | Lead . . . | P. L. . | 640 | 3rd September 1909. | Do. |
| Do. . | (626) T. R. Tawker & Sons. | Tin, lead, copper and iron ore. | P. L. . | 30·60 | 24th December 1909. | 4 months. |
| Do. . | (627) P. Venkatappa . | Lead . . . | P. L. . | 83·00 | 10th December 1909. | 8 months. |
| Do. . | (628) Bavadin & Co. . | Gold . . . | P. L. . | 135·77 | 4th November 1909. | 1 year. |
| Kistna . . | (629) South Indian Coal Mining Co. | Not reported . | E. L. . | All Government villages. | 23rd September 1909. | Do. |
| Kurnool . | (630) A. Ghose . . | Diamond . . | P. L. . | 2,267 | 26th February 1909. | Do. |
| Do. . | (631) Beardsell & Co. . | All minerals . | E. L. . | All Government waste lands, including reserved forests. | 18th January 1909. | Do. |
| Do. . | (632) T. C. Swami & Co. . | Iron ore or any other metal or precious stones. | E. L. . | Not given . | 5th March 1909. | Do. |
| Do. . | (633) Leon Tardival (by Agent). | Diamonds, lead, zinc ores and barytes. | P. L. . | 848·5 | 9th November 1909. | Do. |
| Do. . | (634) W. A. Beardsell & Co. | Manganese . . | P. L. . | 600 | 4th December 1909. | Do. |
| Do. . | (635) Shaik Meera Sahib & Co. | All minerals . | E. L. . | All unoccupied lands. | 19th October 1909. | Do. |
| Do. . | (636) A. Ghose . . | Do. . | P. L. . | 2·18 | 9th November 1909. | Do. |
| Do. . | (637) Abdul Karim Sahib. | Barytes . . | P. L. . | 374 | 15th December 1909. | Do. |
| Do. . | (638) Beardsell & Co. . | Do. . . | P. L. . | 583 | 2nd December 1909. | Do. |
| Nellore . . | (639) P. Venkatarama Nayudu. | Mica . . | M. L. . (patta land) | 15·88 | 4th February 1909. | 20 years. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## MADRAS—*contd.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement | Term. |
|---|---|---|---|---|---|---|
| Nellore . . | (640) D. Venkata Rao . | Mica . . . . | M. L. . | 28·82 | 1st November 1908. | 20 years. |
| Do. . . | (641) L. Chenga Reddi . | Do. . . . . | M. L. . | 18·80 | 12th February 1909. | 30 years. |
| Do. . . | (642) K. Krishnaswami Mudaliyar. | Do. . . . . | P. L. . | 12·02 | 25th February 1909. | 6 months. |
| Do. . . | (643) Kali Chetti Penchal Reddi. | Do. . . . . | P. L. . | 13·13 | 12th March 1909. | 1 year. |
| Do. . . | (644) K. Krishnaswami Mudaliyar. | Do. . . . . | P. L. . | 14·00 | 8th March 1909. | 6 months. |
| Do. . . | (645) Y. Venkatasubbiah and two others. | Do. . . . . | M. L. (patta land) | 303·91 | 17th January 1909. | 20 years. |
| Do. . . | (646) B. Chenchu Ramiah | Do. . . . . | P. L. . | 76·21 | 14th April 1909. | 1 year. |
| Do. . . | (647) M. Gulam Hussain and P. Venkatasubbiah. | Do. . . . . | M. L. (patta land) | 2·75 | 20th June 1909. | 20 years. |
| Do. . . | (648) R. Lakshminarasa Reddi. | Do. . . . . | M. L. . | 6·20 | 14th April 1909. | 30 years. |
| Do. . . | (649) Muhammad Fasiluddin Sahib. | Do. . . . . | M. L. . | 12·30 | 26th March 1909. | Do. |
| Do. . . | (650) K. Adinarayana Reddi. | Do. . . . . | P. L. . | 25·62 | 2nd May 1909 | 1 year. |
| Do. . . | (651) Y. Venkatasubbiah | Do. . . . . | M. L. (patta land) | 7·6 | 14th April 1909. | 20 years. |
| Do. . . | (652) Muhammad Asaruddin Ahmad Sahib. | Do. . . . . | P. L. . | 15·17 | 1st May 1909 | 1 year. |
| Do. . . | (653) P. Balarama Reddi | Do. . . . . | P. L. . | 12·60 | 30th June 1909. | Do. |
| Do. . . | (654) Muhammad Badsha Sahib. | Do. . . . . | P. L. . | 13·98 | 2nd May 1909 | Do. |
| Do. . . | (655) Muhammad Asauddin Ahmad Sahib. | Do. . . . . | P. L. . | 19·72 | 25th May 1909 | Do. |
| Do. . . | (656) George Ellegan . | Do. . . . . | P. L. . | 142·88 | 26th April 1909. | Do. |
| Do . . | (657) K. Panchal Reddi | Do. . . . . | P. L. . | 12·37 | 20th September 1909. | Do. |
| Do. . . | (658) Y. Adema . . | Do. . . . . | M. L. . | 1·28 (patta land) | 7th September 1909. | 20 years. |
| Do. . . | (659) Madras Mica Export Co. . | Do. . . . . | P. L. . | 56·66 | 22nd August 1909. | 1 year. |
| Do. . . | (660) Do. do. . | Do. . . . . | P. L. . | 79·20 | 17th July 1909 | Do. |
| Do. . . | (661) Do. do. . | Do. . . . . | P. L. . | 42·21 | Do. . | Do. |
| Do. . . | (662) P. Venkatarama Nayudu. | Do. . . . . | P. L. . | 13·25 | 22nd September 1909. | Do. |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## MADRAS—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nellore . | (663) G. Illegan . | Mica . | P. L. | 10·86 | 25th July 1909 | 1 year. |
| Do. | (664) Do. do. | Do. | P. L. | 10·45 | Do. | Do. |
| Do. | (665) Do. do. | Do. | P. L. | 12·32 | Do. | Do. |
| Do. | (666) Do. do. | Do. | P. L. | 36·57 | Do. | Do. |
| Do. | (667) Do. do. | Do. | P. L. | 20·75 | Do. | Do. |
| Do. | (668) Muhammad Asar-uddin Sahib. | Do. | E. L. | All unoccupied lands. | 2nd August 1909. | Do. |
| Do. | (669) K. Adinarayan Reddi. | Do. | E. L. | Do. | 29th August 1909. | Do. |
| Do. | (670) B. Balarami Reddi | Do. | M. L. | 23·35 | 10th December 1909. | 30 years. |
| Do. | (671) P. Penchal Reddi . | Do. | M. L. (renewal) | 57·62 | 20th September 1909. | 27 years. |
| Do. | (672) K. Adinarayana Reddi. | Do. | P. L. | 23·00 | 11th December 1909. | 1 year. |
| Do. | (673) N. Obula Reddi | Do. | M. L. | 26·41 | 22nd December 1909. | 30 years. |
| Do. | (674) J. Balarami Reddi. | Do. | M. L. (extension) | 47·00 | 4th December 1909. | 27 years. |
| Do. | (675) V. Venkata Subbayya Nayudu. | Do. | E. L. | All unoccupied lands. | 25th October 1909. | 1 year. |
| Do. | (676) G. Subramanyam . | Do. | P. L. | 11·20 | 4th October 1909. | Do. |
| Salem | (677) Chamber & Co. | Do. | P. L. | 12·97 | 30th January 1909. | Do. |
| Do. | (678) A. T. Tiruvengadaswami Mudaliyar. | Corundum and chromite. | P. L. | 107·04 | 1st May 1909 | Do. |
| South Canara . | (679) Hajee Ismail Sahib | Coal . | E. L. | Whole Taluk | 30th July 1909 | Do. |
| Tinnevelly | (680) Madura Co. . | All minerals | E. L. | 7,277 | 12th December 1909. | Do. |
| Trichinopoly . | (681) Leon Tardival's Agent, Mr. A. Ghose. | Phosphatic nodules and gypsum. | P. L. | 4,522·77 | 29th September 1909. | Do. |

## NORTH-WEST FRONTIER PROVINCE.

| | | | | | | |
|---|---|---|---|---|---|---|
| Hazara . | (682) R. S. Rocha Ram & Sons, Contractors, Abbottabad. | Coal . | M. L. | 19·[illegible]4 | 4th June 1909 | 30 years. |
| Peshawar, Kohat and Bannu. | (683) The Burma Oil Co., Ltd. | Oil | E. L. | British districts of Peshawar, Kohat and Bannu. | 21st April 1909. | 1 year. |

E. L., denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## PUNJAB.

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Jhelum . . | (684) Pandit Bhola Nath | Coal . . . . | P. L. . | 55 | 20th July 1909. | 1 year. |
| Do. . . | (685) Lala Thakur Das Ramjee Das. | Do. . . . . | P. L. . | 92·38 | 3rd October 1909. | Do. |
| Mianwali . | (686) Lala Brindaban . | Do. . . . . | P. L. . | 1,250 | 1st September 1909. | Do. |
| Do. . | (687) Do. do. . | Do. . . . . | Renewal of P. L. . | 1,548 | 20th September 1909. | Do. |
| Shahpur . | (688) Arjan Singh of Kapurthala. | Do. . . . . | P. L. . | 106·19 | 30th June 1909. | Do. |
| Do. . | (689) Do. do. . . | Do. . . . . | P. L. . | 29·66 | Do. . | Do. |
| Do. . | (690) Pir Chan Pir . | Do. . . . . | Renewal of P. L. | 624·3125 | 3rd January 1909. | Do. |

## UNITED PROVINCES.

| | | | | | | |
|---|---|---|---|---|---|---|
| Jhansi . . | (691) Messrs. Dina Nath and Baray Lal Shrivastava. | Copper, lead, silver, mica and other minerals. | P. L. . | 138·52 | 25th January 1909. | 1 year. |
| Do. . . | (692) Do. do. . | Do. . . . | P. L. . . | 1,407·38 | 16th October 1909. | Do. |
| Do. . . | (693) Do. do. . | Do. . . . | P. L. . | 548 | Do. . | Do. |

## SUMMARY.

| Provinces. | Prospecting Licenses. | Exploring Licenses. | Mining Leases. | Total of each Province. |
|---|---|---|---|---|
| Baluchistan . . . . . . . . . | 4 | .. | 5 | 9 |
| Bengal . . . . . . . . . | 11 | .. | 1 | 12 |
| Bombay . . . . . . . . . | 10 | 4 | 3 | 17 |
| Burma . . . . . . . . . | 73 | 19 | 5 | 97 |
| Central Provinces . . . . . . . . | 245 | 107 | 37 | 389 |
| Eastern Bengal and Assam . . . . . | 3 | .. | .. | 3 |
| Madras . . . . . . . . . | 38 | 12 | 14 | 64 |
| North-West Frontier Province . . . . . | .. | 1 | 1 | 2 |
| Punjab . . . . . . . . . | 7 | .. | .. | 7 |
| United Provinces . . . . . . . . | 3 | .. | .. | 3 |
| **Total for each kind and Grand Total, 1909** | **394** | **143** | **156** | **693** |
| *Totals for 1908* . | *508* | *237* | *71* | *816* |

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

## CLASSIFICATION OF LICENSES AND LEASES.

TABLE 21.—*Prospecting and Mining Licenses granted in Baluchistan during 1909.*

| District. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Kalat | 1 | 490 | Coal. |
| Quetta-Pishin | 2 | 12,800 | Do. |
| Sibi | 1 | 1,280 | Do. |
| Total | 4 | .. | |
| **Mining Leases.** | | | |
| Kalat | 1 | 160 | Coal. |
| Quetta-Pishin | 4 | 320 | Chromite. |
| Do. | 16 | 2,610 | Coal. |
| Sibi | 2 | 320 | Do. |
| Zhob | 72 | 6,985·37 | Chromite. |
| Total | 95 | .. | |

TABLE 22.—*Prospecting and Mining Licenses granted in Bengal during 1909.*

| District. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Hazaribagh | 5 | 730 | Mica. |
| Do. | 2 | 2,000 | Other minerals. |
| Sambalpur | 1 | 424·38 | Coal. |
| Singhbhum | 1 | 2,291·20 | Chromite. |
| Do. | 1 | 2,240 | Gold. |
| Do. | 1 | 2,112 | Manganese. |
| Total | 11 | .. | |
| **Mining Leases.** | | | |
| Singhbhum | 1 | 1,920 | Iron ore. |

TABLE 23.—*Prospecting and Mining Licenses granted in Bombay during 1909.*

| District. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Belgaum | 3 | 1,572 | Manganese. |
| Bijapur | 1 | 765 | Asbestos. |
| Do. | 1 | 1,992 | Gold. |
| Kanara | 2 | 2,802 | Manganese, etc. |
| Ratnagiri | 1 | 508 | Chromite. |
| Do. | 1 | 632 | Graphite, etc. |
| Do. | 1 | 475 | Mica and coal. |
| **Total** | **10** | .. | |
| **Mining Leases.** | | | |
| Dharwar | 2 | 2,383 | Gold. |
| Panch Mahals | 1 | 401 | Manganese. |
| **Total** | **3** | .. | |

TABLE 24.—*Prospecting and Mining Licenses granted in Burma during 1909.*

| District. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Amherst | 1 | 309·14 | Antimony. |
| Henzada | 2 | 5,120 | Coal. |
| Do. | 1 | 1,920 | Petroleum. |
| Katha | 1 | 2,880 | Copper. |
| Lower Chindwin | 1 | 14·09 | Iron pyrites. |
| Magwe | 4 | 15,643 | Petroleum. |
| Mandalay | 1 | 484·8 | All minerals except petroleum. |
| Carried over | **11** | .. | |

TABLE 24.—*Prospecting and Mining Licenses granted in Burma during 1909*—contd.

## Prospecting Licenses—*contd.*

| DISTRICT. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| Brought forward | 11 | | |
| Mandalay | 1 | 2,560 | Copper, etc. |
| Do. | 1 | 2,560 | Lead, etc. |
| Do. | 1 | 1,280 | Silver. |
| Meiktila | 1 | 7,680 | Petroleum. |
| Do. | 2 | 2,560 | Lead and copper. |
| Do. | 1 | 2,880 | Coal. |
| Mergui | 1 | 6,362·88 | Tin. |
| Do. | 9 | 16,000 | Tin and gold. |
| Do. | 1 | 2,611·2 | Coal. |
| Minbu | 2 | 4,480 | Petroleum. |
| Myingyan | 10 | 19,194 | Do. |
| Myitkyina | 1 | 640 | Copper, etc. |
| N. Shan States | 1 | 502·65 | Coal. |
| Do. | 2 | 952 | Lead, silver, etc. |
| Pakokku | 9 | 17,920 | Petroleum. |
| Prome | 2 | 30,380·8 | Do. |
| Sagaing | 1 | 550·96 | Iron ore. |
| Salween | 2 | 5,760 | Lead and silver. |
| Shwebo | 1 | 320 | Iron ore. |
| S. Shan States | 2 | 4,800 | Copper, etc. |
| Do. | 1 | 3,200 | Lead, copper, etc. |
| Do. | 2 | 5,120 | Wolfram. |
| Tavoy | 2 | 3,520 | Tin, wolfram, etc. |
| Thatôn | 2 | 6,400 | Gold etc. |
| Do. | 1 | 2,560 | Lead and silver. |
| Toungoo | 2 | 4,549 | Lead, silver, etc. |
| Upper Chindwin | 1 | 5,760 | Petroleum |
| Total | 73 | .. | |

## Mining Leases.

| DISTRICT. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| Bhamo | 1 | 1,568 | Gold. |
| Magwe | 1 | 688 | Petroleum. |
| Pakokku | 1 | 1,289 | Do. |
| S. Shan States | 1 | 7·38 | Lead and silver. |
| Upper Chindwin | 1 | 1,920 | Coal. |
| Total | 5 | .. | |

TABLE 25.—*Prospecting and Mining Licenses granted in the Central Provinces during 1909.*

| DISTRICT. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Balaghat | 21 | 7,383 | Manganese. |
| Do. | 1 | 285 | Mica. |
| Betul | 5 | 9,391 | Coal. |
| Do. | 1 | 8,890 | Coal, copper, etc. |
| Do. | 2 | 610 | Graphite. |
| Do. | 1 | 148 | Manganese. |
| Bhandara | 70 | 14,328 | Do. |
| Do. | 1 | 1,300 | Manganese, tin, etc. |
| Chanda | 2 | 4,339 | Coal. |
| Chhindwara | 2 | 5,881 | Do. |
| Do. | 9 | 899 | Manganese. |
| Drug | 1 | 167 | Lead and quicksilver. |
| Jubbulpore | 2 | 663 | Bauxite. |
| Do. | 6 | 1,135 | Manganese. |
| Do. | 2 | 663 | Manganese and iron. |
| Do. | 1 | 633 | Iron. |
| Do. | 1 | 86 | Coal. |
| Do. | 2 | 863 | Soapstone and talc. |
| Nagpur | 90 | 15,085 | Manganese. |
| Do. | 12 | 3,850 | Manganese and other minerals. |
| Do. | 2 | 317 | Lead ore. |
| Do. | 1 | 53 | Copper. |
| Do. | 1 | 107 | Mica. |
| Do. | 1 | 231 | Wolfram. |
| Raipur | 2 | 1,479 | Graphite. |
| Do. | 1 | 114 | Lead. |
| Do. | 1 | 2,381 | Manganese, etc. |
| Saugor | 1 | 368 | Gold, silver, etc. |
| Seoni | 1 | 46 | Manganese. |
| Do. | 1 | 2,292 | Iron ore. |
| Wardha | 1 | 2,715 | Coal. |
| Total | 245 | .. | |
| **Mining Leases.** | | | |
| Balaghat | 5 | 257 | Manganese. |
| Bhandara | 17 | 1,861 | Do. |
| Chhindwara | 2 | 41 | Do. |
| Jubbulpore | 1 | 49 | Gold, silver, copper and lead. |
| Nagpur | 12 | 761 | Manganese. |
| Total | 37 | .. | |

TABLE 26.—*Prospecting Licenses granted in Eastern Bengal and Assam during 1909.*

| DISTRICT. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
| --- | --- | --- | --- |
| Chittagong | 1 | 2,675 | Coal, oil, etc. |
| Lakhimpur | 2 | 31,916 | Coal, etc. |
| Total | 3 | .. | |

TABLE 27.—*Prospecting and Mining Licenses granted in Madras during 1909.*

| DISTRICT. | 1909. No. | 1909. Area in acres. | 1909. Mineral. |
| --- | --- | --- | --- |
| **Prospecting Licenses.** | | | |
| Coimbatore | 1 | 5,445·90 | Corundum, asbestos, etc. |
| Do. | 1 | 211·92 | Mica. |
| Cuddapah | 3 | 1,299·88 | Lead ore. |
| Do. | 1 | 30·60 | Tin, lead, etc. |
| Do. | 1 | 135·77 | Gold. |
| Kurnool | 1 | 2,267 | Diamonds. |
| Do. | 1 | 848·5 | Diamonds, lead, etc. |
| Do. | 1 | 600 | Manganese. |
| Do. | 2 | 957 | Barytes. |
| Do. | 1 | 2·18 | All minerals. |
| Nellore | 22 | 675 | Mica. |
| Salem | 1 | 12·97 | Do. |
| Do. | 1 | 107·04 | Corundum and chromite. |
| Trichinopoly | 1 | 4,522·77 | Phosphatic nodules and gypsum. |
| Total | 38 | .. | |
| **Mining Leases.** | | | |
| Bellary | 1 | 1,591·29 | Manganese. |
| Nellore | 13 | 551·92 | Mica. |
| Total | 14 | .. | |

TABLE 28.—*Mining Leases granted in the North-West Frontier Province during 1909.*

| District. | No. | Area in acres. | Mineral. |
|---|---|---|---|
| Hazara | 1 | 19·14 | Coal. |

TABLE 29.—*Prospecting Licenses granted in the Punjab during 1909.*

| District. | No. | Area in acres. | Mineral. |
|---|---|---|---|
| Jhelum | 2 | 147·38 | Coal. |
| Mianwali | 2 | 2,798 | Do. |
| Shahpur | 3 | 760·16 | Do. |
| Total | 7 | .. | |

TABLE 30.—*Prospecting Licenses granted in the United Provinces during 1909.*

| District. | No. | Area in acres. | Mineral. |
|---|---|---|---|
| Jhansi | 3 | 2,093·9 | Copper, lead, etc. |

TABLE 31.—*Summary of concessions granted in Government lands during the ten years 1900-1909.*

| Year. | Mining and Prospecting Licenses. | Exploring Licenses. | Total. |
|---|---|---|---|
| 1900 | 61 | 11 | 72 |
| 1901 | 89 | 15 | 104 |
| 1902 | 89 | 16 | 105 |
| 1903 | 84 | 16 | 100 |
| 1904 | 125 | 26 | 151 |
| 1905 | 145 | 44 | 189 |
| 1906 | 211 | 41 | 252 |
| 1907 | 539 | 61 | 600 |
| 1908 | 579 | 237 | 816 |
| 1909 | 550 | 143 | 692 |

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VOL. XI, 1878.

*Part 1.*—Annual report for 1887. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palæontological relations of Gondwana system. 'Erratics in Punjab.'

*Part 2.*—Geology of Sind (second notice). Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.

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*Part 4.*—Geological distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

*Part 1.*—Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour through Hangrang and Spiti. Mud eruption in Ramri Island (Arakan). Braunite, with Rhodonite, from Nagpur, Central Provinces. Palæontological notes from Satpura coal basin. Coal importations into India.

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*Part 4.*—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

VOL. XIII, 1880.

*Part 1.*—Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Fossil plants from Kattywar, Shekh Budin, and Sirgujah. Volcanic foci of eruption in Konkan.

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*Part 4.*—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australian coal-bearing system. Reh or alkali soils and saline well waters. Reh soils of Upper India. Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

*Part 1.*—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

*Part 2.*—Nahan-Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Ossiferous beds of Hundes in Tibet. Mining records and mining record office of Great Britain; and Coal and Metalliferous Mines Acts of 1872 (England). Cobaltite and danaite from Khetri mines, Rajputana; with remarks on Jaipurite (Syepoorite). Zinc-ore (Smithsonite and Blende) with barytes in Karnul district, Madras. Mud eruption in island of Cheduba.
*Part 3.*—Artesian borings in India. Oligoclase granite at Wangtu on Sutlej, North-West Himalayas. Fish-palate from Siwaliks. Palæontological notes from Hazaribagh and Lohardagga districts. Fossil carnivora from Siwalik hills.
*Part 4.*—Unification of geological nomenclature and cartography. Geology of Arvali region, central and eastern. Native antimony obtained at Pulo Obin, near Singapore. Turgite from Juggiapett, Kistnah district, and zinc carbonate from Karnul, Madras. Section from Dalhousie to Pangi, *viâ* Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

## Vol. XV, 1882.

*Part 1 (out of print).*—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Noa-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) koalin at Darjiling Analyses of coal and fire-clay from Makum coal field, Upper Assam. Experiments on coal of Pind Dadun Khan, Salt-range, with reference to production of gas, made April 29th, 1881 Proceedings of International Congress of Bologna.
*Part 2 (out of print).*—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal-bearing rocks of Upper Rer and Mand rivers in Western Chutia Nagpur. Pench river coal-field in Chhindwara district, Central Provinces Borings for coal at Engsein, British Burma. Sapphires in North Western Himalaya. Eruption of mud volcanoes in Cheduba.
*Part 3.*—Coal of Mach (Much) in Bolan Pass, and of Sharigh on Harnai route between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. Traps of Darang and Mandi in North-Western Himalayas Connexion between Hazara and Kashmir series. Umaria coal-field (South Rewah Gondwana basin) Daranggiri coal-field, Garo Hills, Assam. Coal in Myanoung division, Henzada district.
*Part 4 (out of print).*—Gold fields of Mysore Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna

## Vol. XVI, 1883.

*Part 1*—Annual report for 1882 Richthofenia, Kays (Anomia Lawrenciana, Koninck) Geology of South Travancore Geology of Chamba. Basalts of Bombay.
*Part 2.*—Synopsis of fossil vertebrata of India Bijori Labyrinthodont. Skull of Hippotherium antilopinum. Iron ores, and subsidiary materials for manufacture of iron, in north-eastern part of Jabalpur district. Laterite and other manganese ore occurring at Gosulpore, Jabalpur district Umaria coal field
*Part 3.*—Microscopic structure of some Dalhousie rocks. Lavas of Aden Probable occurrence of Siwalik strata in China and Japan Mastodon angustidens in India. Traverse between Almora and Mussooree Cretaceous coal measures at Borsora, in Khasia Hills, near Laour, in Sylhet.
*Part 4*—Palæontological notes from Daltonganj and Hutar coal-fields in Chota Nagpur. Altered basalts of Dalhousie region in North-Western Himalayas. Microscopic structure of some Sub Himalayan rocks of tertiary age. Geology of Jaunsar and Lower Himalayas. Traverse through Eastern Khasia, Jaintia, and North Cachar Hills. Native lead from Maulmain and chromite from the Andaman Islands. Every eruption from one of mud volcanoes of Cheduba Island, Arakan. Irrigation from wells in North-Western Provinces and Oudh

## Vol. XVII, 1884.

*Part 1.*—Annual report for 1883. Smooth water anchorages or mud-banks of Narrakal and Alleppy on Travancore coast. Billa Surgam and other caves in Kurnool district. Geology of Chauari and Sihunta parganas of Chamba. Lyttonia, Waagen, in Kuling series of Kashmir.
*Part 2.*—Earthquake of 31st December 1881, Microscopic structure of some Himalayan granites and gneissose granites. Choi coal exploration. Re-discovery of fossils in Siwalik beds. Mineral resources of the Andaman Islands in neighbourhood of Port Blair. Intertrappean beds in Deccan and Laramie group in Western North America.

*Part 3 (out of print).*—Microscopic structure of some Arvali rocks. Section along Indus from Peshawar Valley to Salt-range. Sites for boring in Raigarh-Hingir coal-field (first notice). Lignite near Raipore, Central Provinces. Turquoise mines of Nishápúr, Khorassan. Fiery eruption from Minbyin mud volcano of Cheduba Island, Arakan. Lungrin coal-field, South-Western Khasia Hills. Umaria coal-field.

*Part 4.*—Geology of part of Gangasulan pargana of British Garhwal. Slates and schists imbedded in gneissose granite of North-West Himalayas. Geology of Takht-i-Suleiman. Smooth-water anchorages of Travancore coast. Auriferous sands of the Subansiri river, Pondicherry lignite, and phosphatic rocks at Musuri. Billa Surgam caves.

## Vol. XVIII, 1885.

*Part 1.*—Annual report for 1884. Country between Singareni coal-field and Kistna river. Geological sketch of country between Singareni coal-field and Hyderabad. Coal and limestone in Doigrung river near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

*Part 2.*—Fossiliferous series in Lower Himalaya, Garhwal. Age of Mandhali series in Lower Himalaya. Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). Geology of Chamba. Probability of obtaining water by means of artesian wells in plains of Upper India. Artesian sources in plains of Upper India. Geology of Aka Hills. Alleged tendency of Arakan mud volcanoes to burst into eruption most frequently during rains. Analyses of phosphatic nodules and rock from Mussooree.

*Part 3.*—Geology of Andaman Islands. Third species of Merycopotamus. Percolation as affected by current. Pirthalla and Chandpur meteorites. Oil-wells and coal in Thayetmyo district, British Burma. Antimony deposits in Maulmain district. Kashmir earthquake of 30th May 1885. Bengal earthquake of 14th July 1885.

*Part 4.*—Geological work in Chhattisgarh division of Central Provinces. Bengal earthquake of 14th July 1885. Kashmir earthquake of 30th May 1885. Excavations in Billa Surgam caves. Nepaulite. Sabetmahet meteorite.

## Vol. XIX, 1886.

*Part 1.*—Annual report for 1885. International Geological Congress of Berlin. Palæozoic Fossils in Olive group of Salt-range Correlation of Indian and Australian coal-bearing beds Afghan and Persian Field notes Section from Simla to Wangtu, and petrological character of Amphibolites and Quartz Diorites of Sutlej valley.

*Part 2.*—Geology of parts of Bellary and Anantapur districts. Geology of Upper Dehing basin in Singpho Hills. Microscopic characters of eruptive rocks from Central Himalayas Mammalia of Karnul Caves. Prospects of finding coal in Western Rajputana. Olive group of Salt-range. Boulder-beds of Salt-range. Gondwana Homotaxis.

*Part 3.*—Geological sketch of Vizagapatam district, Madras. Geology of Northern Jesalmer. Microscopic structure of Malani rocks of Arvali region. Malanjkhandi copper-ore in Balaghat district, C. P.

*Part 4 (out of print).*—Petroleum in India. Petroleum exploration at Khátan. Boring in Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Nammianthal aerolite. Analysis of gold dust from Meza valley, Upper Burma.

## Vol. XX, 1887.

*Part 1.*—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jaunsar-Bawar and Tiri-Garhwal. Geology of Garo Hills. Indian image-stones. Soundings recently taken off Barren Island and Narcondam. Talchir boulder-beds. Analysis of Phosphatic Nodules from Salt-range, Punjab.

*Part 2.*—Fossil vertebrata of India. Echinoidea of cretaceous series of Lower Narbada Valley. Field-notes: No. 5—to accompany geological sketch map of Afghanistan and North-Eastern Khorassan. Microscopic structure of Rajmahal and Deccan traps. Dolerite of Chor. Identity of Olive series in east with speckled sandstone in west of Salt-range in Punjab.

*Part 3.*—Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section I. Geology of Simla and Jutogh. 'Lalitpur' meteorite.

*Part 4.*—Points in Himalayan geology. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section II. Iron industry of western portion of Raipur. Notes on Upper Burma. Boring exploration in Chattisgarh coal-fields. (Second notice). Pressure Metamorphism, with reference to foliation of Himalayan Gneissose Granite. Papers on Himalayan Geology and Microscopic Petrology.

## Vol. XXI, 1888.

*Part 1.*—Annual report for 1887. Crystalline and metamorphic rocks of Lower Himalayas, Garhwal, and Kumaun, Section III. Birds'-nest of Elephant Island, Mergui Archipelago. Exploration of Jessalmer, with a view to discovery of coal. Facetted pebbles from boulder bed ('speckled sandstone') of Mount Chel in Salt-range, Punjab. Nodular stones obtained off Colombo.

*Part 2.*—Award of Wollaston Gold Medal, Geological Society of London, 1888. Dharwar System in South India. Igneous rocks of Raipur and Balaghat, Central Provinces. Sangar Marg and Mehowgale coal-fields, Kashmir.

*Part 3.*—Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' Pre-tertiary sedimentary formations of Simla region of Lower Himalayas.

*Part 4.*—Indian fossil vertebrates. Geology of North-West Himalayas. Blown-sand rock sculpture. Nummulites in Zanskar. Mica traps from Barakar and Raniganj.

## Vol. XXII, 1889.

*Part 1 (out of print).*—Annual report for 1888. Dharwar System in South India. Wajra Karur diamonds, and M. Chaper's alleged discovery of diamonds in pegmatite. Generic position of so-called Plesiosaurus Indicus. Flexible sandstone or Itacolumite, its nature, mode of occurrence in India, and cause of its flexibility. Siwalik and Narbada Chelonia.

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*Part 3.*—Coal outcrops in Sharigh Valley, Baluchistan. Trilobites in Neobolus beds of Salt-range. Geological notes. Cherra Poonjee coal-field, in Khasia Hills. Cobaltiferous Matt from Nepál. President of Geological Society of London on International Geological Congress of 1888. Tin-mining in Mergui district.

*Part 4 (out of print).*—Land-tortoises of Siwaliks. Pelvis of a ruminant from Siwaliks. Assays from Sambhar Salt-Lake in Rajputana. Manganiferous iron and Manganese Ores of Jabalpur. Palagonite-bearing traps of Rájmahál hills and Deccan. Tin-smelting in Malay Peninsula. Provisional Index of Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones and Quarry Stones in Indian Empire. Part 1.

## Vol. XXIII, 1890

*Part 1.*—Annual report for 1889. Lakadong coal-fields, Jaintia Hills. Pectoral and pelvic girdles and skull of Indian Dicynodonts. Vertebrate remains from Nagpur district (with description of fish-skull). Crystalline and metamorphic rocks of Lower Himalayas, Garhwál and Kumaun, Section IV. Bivalves of Olive-group, Salt-range. Mud-banks of Travancore coasts.

*Part 2 (out of print).*—Petroleum explorations in Harnai district, Baluchistan. Sapphire Mines of Kashmir. Supposed Matrix of Diamond at Wajra Karur, Madras. Sonapet Gold-field. Field-notes from Shan Hills (Upper Burma). New species of Syringosphæridæ.

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## Vol. XXIV, 1891.

*Part 1.*—Annual report for 1890. Geology of Salt-range of Punjab, with re-considered theory of Origin and Age of Salt-Marl. Graphite in decomposed Gneiss (Laterite) in Ceylon. Glaciers of Kabru, Pandim, etc. Salts of Sambhar Lake in Rajputana, and 'Reh' from Aligarh in North-Western Provinces. Analysis of Dolomite from Salt-range, Punjab.

*Part 2.*—Oil near Moghal Kot, in Sheráni country, Suleiman Hills. Mineral Oil from Suleiman Hills. Geology of Lushai Hills. Coal-fields in Northern Shan States. Reported Namseka Ruby-mine in Mainglôn State. Tourmaline (Schorl) Mines in Mainglôn State.—Salt-spring near Bawgyo, Thibaw State.

Part 3 (out of print).—Boring in Daltonganj Coal-field, Palamow. Death of Dr. P. Martin Duncan. Pyroxenic varieties of Gneiss and Scapolite-bearing Rocks.
Part 4.—Mammalian Bones from Mongolia. Darjiling Coal Exploration. Geology and Mineral Resources of Sikkim. Rocks from the Salt-range, Punjab.

Vol. XXV, 1892.

Part 1.—Annual report for 1891. Geology of Thal Chotiáli and part of Mari country. Petrological Notes on Boulder-bed of Salt-range, Punjab. Sub-recent and Recent Deposits of valley plains of Quetta, Pishin, and Dasht-i-Bedaolat; with appendices on Chamans of Quetta; and Artesian water-supply of Quetta and Pishin.
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*Part 4.*—Oil Springs at Moghal Kot in Shirani Hills. Mineral Oil from Suleiman Hills. New Amber-like Resin in Burma. Triassic Deposits of Salt-range.

Vol. XXVI, 1893.

*Part 1.*—Annual report for 1892. Central Himalayas. Jadeite in Upper Burma. Burmite, new Fossil Resin from Upper Burma. Prospecting Operations, Mergui District, 1891-92.
*Part 2.*—Earthquake in Baluchistan on 20th December 1892. Burmite, new amber-like fossil resin from Upper Burma. Alluvial deposits and Subterranean water-supply of Rangoon.
*Part 3.*—Geology of Sherani Hills. Carboniferous Fossils from Tenasserim. Boring at Chandernagore. Granite in Tavoy and Mergui.
*Part 4.*—Geology of country between Chappar Rift and Harnai in Baluchistán. Geology of part of Tenasserim Valley with special reference to Tendau-Kamapying Coal-field. Magnetite containing Manganese and Alumina. Hislopite.

Vol. XXVII, 1894.

*Part 1.*—Annual report for 1893. Bhaganwala Coal-field, Salt-range, Punjab.
*Part 2.*—Petroleum from Burma. Singareni Coal field, Hyderabad (Deccan). Gohna Landslip, Garhwal.
*Part 3.*—Cambrian Formation of Eastern Salt-range. Giridih (Karharbari) Coal-fields. Chipped (?) Flints in Upper Miocene of Burma. Velates Schmideliana, Chemn., and Provelates grandis, Sow. sp., in Tertiary Formation of India and Burma.
*Part 4.*—Geology of Wuntho in Upper Burma. Echinoids from Upper Cretaceous System of Baluchistán. Highly Phosphatic Mica Peridotites intrusive in Lower Gondwana Rocks of Bengal. Mica-Hyperstheme-Hornblende-Peridotite in Bengal.

Vol. XXVIII, 1895.

*Part 1.*—Annual report for 1894. Cretaceous Formation of Pondicherry. Early allusion to Barren Island. Bibliography of Barren Island and Narcondam from 1884 to 1894.
*Part 2.*—Cretaceous Rocks of Southern India and geographical conditions during later cretaceous times. Experimental Boring for Petroleum at Sukkur from October 1893 to March 1895. Tertiary system in Burma.
*Part 3.*—Jadeite and other rocks, from Tammaw in Upper Burma. Geology of Tochi Valley. Lower Gondwanas in Argentina.
*Part 4.*—Igneous Rocks of Giridih (Kurhurbaree) Coal-field and their Contact Effects. Vindhyan system south of Sone and their relation to so-called Lower Vindhyans. Lower Vindhyan area of Sone Valley. Tertiary system in Burma.

Vol. XXIX, 1896.

*Part 1.*—Annual report for 1895. Acicular inclusions in Indian Garnets. Origin and Growth of Garnets and of their Micropegmatitic intergrowths in Pyroxenic rocks.
*Part 2.*—Ultra-basic rocks and derived minerals of Chalk (Magnesite) hills, and other localities near Salem, Madras. Corundum localities in Salem and Coimbatore districts, Madras. Corundum and Kyanite in Manbhum district, Bengal. Ancient Geography of "Gondwanaland." Notes.
*Part 3.*—Igneous Rocks from the Tochi Valley. Notes.
*Part 4.*—Steatite mines, Minbu district, Burma. Lower Vindhyan (Sub-Kaimur) area of Sone Valley, Rewah. Notes.

Vol. XXX, 1897.

*Part 1.*—Annual report for 1896. Norite and associated Basic Dykes and Lava-flows in Southern India. Genus Vertebraria. On Glossopteris and Vertebraria.

*Part 2*.—Cretaceous Deposits of Pondicherri. Notes.

*Part 3*.—Flow structure in igneous dyke. Olivine-norite dykes at Coonoor. Excavations for corundum near Palakod, Salem District. Occurrence of coal at Palana in Bikanir. Geological specimens collected by Afghan-Baluch Boundary Commission of 1896.

*Part 4*.—Nemalite from Afghanistan. Quartz-barytes rock in Salem district, Madras Presidency. Worn femur of Hippopotamus irravadicus, Caut. and Falc., from Lower Pliocene of Burma. Supposed coal at Jaintia, Baxa Duars. Percussion Figures on micas. Notes.

VOL. XXXI, 1904.

*Part 1 (out of print)*.—Prefatory Notice. Copper-ore near Komai, Darjeeling district. Zewan beds in Vihi district, Kashmir. Coal deposits of Isa Khel, Mianwali district, Punjab. Um-Rileng coal-beds, Assam. Sapphirine-bearing rock from Vizagapatam district. Miscellaneous Notes. Assays.

*Part 2 (out of print)*.—Lt.-Genl. C. A. McMahon. Cyclobus Haydeni Diener. Auriferous Occurrences of Chota Nagpur, Bengal. On the feasibility of introducing modern methods of Coke-making at East Indian Railway Collieries, with supplementary note by Director, Geological Survey of India. Miscellaneous Notes.

*Part 3 (out of print)*.—Upper Palæozoic formations of Eurasia. Glaciation and History of Sind Valley. Halorites in Trias of Baluchistan. Geology and Mineral Resources of Mayurbhanj. Miscellaneous Notes.

*Part 4 (out of print)*.—Geology of Upper Assam. Auriferous Occurrences of Assam. Curious occurrence of Scapolite from Madras Presidency. Miscellaneous Notes. Index.

VOL. XXXII, 1905.

*Part 1 (out of print)*.—Review of Mineral Production of India during 1898—1903.

*Part 2 (out of print)*.—General report, April 1903 to December 1904. Geology of Provinces of Tsang and Ü in Tibet. Bauxite in India. Miscellaneous Notes.

*Part 3 (out of print)*.—Anthracolithic Fauna from Subansiri Gorge, Assam. Elephas Antiquus (Namadicus) in Godavari Alluvium. Triassic Fauna of Tropites-Limestone of Byans. Amblygonite in Kashmir. Miscellaneous Notes.

*Part 4*.—Obituary notices of H. B. Medlicott and W. T. Blanford. Kangra Earthquake of 4th April 1905. Index to Volume XXXII.

VOL. XXXIII, 1906.

*Part 1 (out of print)*.—Mineral Production of India during 1904. Pleistocene Movement in Indian Peninsula. Recent Changes in Course of Nam-tu River, Northern Shan States. Natural Bridge in Gokteik Gorge. Geology and Mineral Resources of Narnaul District (Patiala State). Miscellaneous Notes.

*Part 2 (out of print)*.—General report for 1905. Lashio Coal-field, Northern Shan States. Namma, Mansang and Man-se-le Coal-fields, Northern Shan States, Burma. Miscellaneous Notes.

*Part 3 (out of print)*.—Petrology and Manganese-ore Deposits of Sausar Tahsil, Chhindwara district, Central Provinces. Geology of part of valley of Kanhan River in Nagpur and Chhindwara districts, Central Provinces. Manganite from Sandur Hills. Miscellaneous Notes.

*Part 4 (out of print)*.—Composition and Quality of Indian Coals. Classification of the Vindhyan System. Geology of State of Panna with reference to the Diamond-bearing Deposits. Index to Volume XXXIII.

VOL. XXXIV, 1906.

*Part 1*.—Fossils from Halorites Limestone of Bambanag Cliff, Kumaon. Upper-Triassic Fauna from Pishin District, Baluchistan. Geology of portion of Bhutan. Coal Occurrences in Foot-hills of Bhutan. Dandli Coal-field: Coal outcrops in Kotli Tehsil of Jammu State. Miscellaneous Notes.

*Part 2 (out of print)*.—Mineral Production of India during 1905. Nummulites Douvillei, with remarks on Zonal Distribution of Indian Nummulites. Auriferous Tracts in Southern India. Abandonment of Collieries at Warora, Central Provinces. Miscellaneous Notes.

*Part 3*.—Explosion Craters in Lower Chindwin district, Burma. Lavas of Pavagad Hill. Gibbsite with Manganese-ore from Talevadi, Belgaum district, and Gibbsite from Bhekowli, Satar District. Classification of Tertiary System in Sind with reference to Zonal distribution of Eocene Echinoidea.

*Part 4 (out of print)*.—Jaipur and Nazira Coal-fields, Upper Assam. Makum Coal-fields between Tirap and Namdang Streams. Kabat Anticline, near Seiktein, Myingyan district, Upper Burma. Asymmetry of Yenangyat-Singu Anticline, Upper Burma. Northern part of Gwegyo Anticline, Myingyan District, Upper Burma. Breynia Multituberculata, from Nari of Baluchistan and Sind. Index to Volume XXXIV.

## Vol. XXXV, 1907.

*Part 1 (out of print).*—General report for 1906. Orthophragmina and Lepidocyclina in Nummulitic Series. Meteoric Shower of 22nd October 1903 at Dokáchi and neighbourhood, Dacca district.

*Part 2.*—Indian Aerolites. Brine-wells at Bawgyo, Northern Shan States. Gold-bearing Deposits of Loi Twang, Shan States. Physa Prinsepii in Maestrichtian strata of Baluchistan. Miscellaneous Notes.

*Part 3.*—Preliminary survey of certain Glaciers in North-West Himalaya. A.—Notes on certain Glaciers in North-West Kashmir.

*Part 4.*—Preliminary survey of certain Glaciers in North-West Himalaya. B.—Notes on certain Glaciers in Lahaul. C.—Notes on certain Glaciers in Kumaon. Index to Volume XXXV.

## Vol. XXXVI, 1907-08.

*Part 1.*—Petrological Study of Rocks from hill tracts, Vizagapatam district, Madras Presidency. Nepheline Syenites from hill tracts, Vizagapatam district, Madras Presidency. Stratigraphical Position of Gangamopteris Beds of Kashmir. Volcanic outburst of Late Tertiary Age in South Hsenwi, N. Shan States. New suidæ from Bugti Hills, Baluchistan. Permo-Carboniferous Plants from Kashmir.

*Part 2 (out of print).*—Mineral Production of India during 1906. Ammonites of Bagh Beds. Miscellaneous Notes.

*Part 3.*—Marine fossils in Yenangyaung oil-field, Upper Burma. Fresh-water shells of genus Batissa in Yenangyaung oil-field, Upper Burma. New Species of Dendrophyllia from Upper Miocene of Burma. Structure and age of Taungtha hills, Myingyan district, Upper Burma. Fossils from Sedimentary rocks of Oman (Arabia). Rubies in Kachin hills, Upper Burma. Cretaceous Orbitoides of India. Two Calcutta Earthquakes of 1906. Miscellaneous Notes.

*Part 4.*—Pseudo-Fucoids from Pab sandstones at Fort Munro, and from Vindhyan series. Jadeite in Kachin Hills. Upper Burma. Wetchok-Yedwet Pegu outcrop, Magwe district, Upper Burma. Group of Manganates, comprising Hollandite, Psilomelane and Coronadite. Occurrence of Wolfram in Nagpur district, Central Provinces. Miscellaneous Notes. Index to Volume XXXVI.

## Vol. XXXVII, 1908-09.

*Part 1.*—General report for 1907. Mineral Production of India during 1907. Occurrence of striated boulders in Blaini formation of Simla. Miscellaneous Notes.

*Part 2.*—Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind. Geology and Mineral Resources of Rajpipla State. Suitability of sands in Rajmahal Hills for glass manufacture. Three new Manganese-bearing minerals :—Vredenburgite, Sitaparite and Juddite. Laterites from Central Provinces. Miscellaneous Notes.

*Part 3.*—Southern part of Gwegyo Hills, including Payagyigon-Ngashandaung Oil-field. Silver-lead mines of Bawdwin, Northern Shan States. Mud volcanoes of Arakan Coast, Burma.

*Part 4.*—Gypsum Deposits in Hamirpur district, United Provinces. Gondwanas and related marine sedimentary system of Kashmir. Miscellaneous Notes. Index to Volume XXXVII.

## Vol. XXXVIII, 1909.

*Part 1.*—General report for 1908. Mineral Production of India during 1908.

*Part 2.*—Ostrea latimarginata in Burma. China-clay and Fire-clay of Rajmahal Hills. Coal at Gilhurria. Pegu Inlier at Ondwe. Salt Deposits of Rajputana. Miscellaneous Notes.

*Part 3.*—Geology of Sarawan, Jhalawan and Las Bela. Hippurite limestone in Seistan. Afghan Fusulinidæ. Miscellaneous Notes.

*Part 4.*—Western Prome and Kama. Recorrelation of Pegu system. Pegu fossil fish-teeth. Yenangyat Oil-field. Iron-ores of Chanda. Geology of Aden Hinterland. Petrography of Aden Hinterland. Fossils from Aden Hinterland. Miscellaneous Notes. Index to Volume XXXVIII.

## Vol. XXXIX, 1910.

Quinquennial Review of Mineral Production for 1904 to 1908.

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OF

# THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1910. [October.


## PRELIMINARY NOTE ON A REVISED CLASSIFICATION OF THE TERTIARY FRESHWATER DEPOSITS OF INDIA. BY GUY E. PILGRIM, D.SC., F.G.S., *Geological Survey of India*.

PERHAPS a few words of explanation are needed on the publication of this note, so disproportionately slight as compared with the importance of the conclusions which I seek to establish. Through my omission of the names of localities and of the details of stratigraphical structure, I give little opportunity to another to satisfy himself as to the truth of the facts adduced. My reason for not publishing in complete detail the stratigraphical results so far attained is that I still remain unacquainted with large areas in the north-west of India; and although I feel convinced that the examination of these cannot disprove my conclusions in any important particular, still I am averse from publishing detailed geological descriptions of any part of India, when we are still proceeding with the survey of that part and may reasonably hope to finish it at no distant period. A sufficient argument against delaying it entirely, will, I think, appear in the fact that a concordant classification of the Tertiary freshwater strata of India is essential to enable one to deal satisfactorily with fresh collections of vertebrates, which are coming in year by year from India and the adjacent countries. One attempt in this direction has already been made by the writer, by separating the lower portion of the ossiferous beds of India into two series and assigning to them different

ages. Much as this was needed in Sind and the Bugti Hills, still more is this the case in the Punjab and the Siwalik Hills. For in Sind and the Bugti Hills it had, at all events, been recognised that the fossils there found were the oldest of the "Siwalik group," so called, whereas from north-west India we possess descriptions of considerably over a hundred species of vertebrates, of which all we really know is that they are derived somewhere out of a series of beds some 16,000 to 20,000 feet thick. No reason has been given us for regarding any of these species as more characteristic of one stratigraphical horizon than of another, and if we relied only on the early observations and not on our sense of probability we should expect to find the same species in the top bed as in the bottom. The conflicting character of the species has for long suggested to most palæontologists the extreme improbability of their all being of the same age. So strongly has this been felt, that an admixture of the species has been tacitly assumed; but no fresh facts on the question have accumulated for many years and no table showing the distribution of the various mammalian species exists. This omission it is now my purpose to supply and at the same time to show as far as possible the relation of the various beds to one another.

Even though this is only a preliminary note, still I shall endeavour to state sufficient facts to afford plausible reasons for the classification adopted.

One more point is perhaps worth mentioning. Of the numerous correlations of these beds, which have been suggested by Medlicott, Wynne, Theobald and others, none have been supported by more than the supposed lithological resemblance between the various beds; in no case has one fossil identity been adduced as evidence. Valuable as lithological resemblances may be as confirmatory evidence, much weight must not be attached to them alone in the case of such variable deposits as those produced by rivers. Consequently in what follows the chief stress will be laid on the palæontological evidence, and as the fossils were carefully collected, if not always either by myself or by my assistant Mr. Vinayak Rao personally, yet with an intimate knowledge of the exact locality where they occur, I do not think there are now many species of whose exact horizon we are unaware.

The following is a list of geological maps dealing with different portions of the north-west of India, which have been published

from time to time by the Geological Survey of India. These will render clearer the geographical distribution of the Tertiary deposits referred to in the following pages.

The most comprehensive map, though rather out of date and inaccurate, is Wynne's, in *Rec. Geol. Surv. Ind.*, Vol. X, Pt. 3, p. 109. The following deal with special areas :—

Salt Range: *Mem. Geol. Surv. Ind.*, Vol. XIV.

Kohat and Bannu: *Mem. Geol. Surv. Ind.*, Vols. XVII, Pt. 2, and XI, Pt. 2.

Murree Hills and Kashmir: *Mem. Geol. Surv. Ind.*, Vols. XXII and XXIV, Pt. 2.

Kangra and Siwalik Hills: *Mem. Geol. Surv. Ind.*, Vols. III, Pt. 2, and XXIV, Pt. 2.

Sherani Hills: *Rec. Geol. Surv. Ind.*, Vol. XXVI, p. 77.

Bugti Hills and Dera Ghazi Khan: *Mem. Geol. Surv. Ind.*, Vol. XX, Pt. 2.[1]

## The Upper Nari.

In a former paper I have shown[2] that river deposits of Upper Nari (aquitanian) age have been traced through the Bugti Hills to some distance beyond Dera Ghazi Khan. I have now found that these beds are clearly represented over a large part of north-west India. In the Bugti Hills a great unconformity occurs between the Upper Nari beds and the Lower Siwaliks. If we go north to the Kala Chitta Range, running between the Indus river and Rawal Pindi, and to the Murree Hills, we shall have indubitable evidence that here the interval is bridged over by an existing deposit. Here is developed a great mass of strata, from 4,000 to 8,000 feet thick known as the Murree series. Conformably beneath them and resting on the Khirthars are beds of calcareous conglomerate and sandstone and red shale—the Kuldana beds of Wynne[3] and Middlemiss.[4] These

[1] A revised map of part of this area is now in the press and will shortly be published in *Pal. Ind.*, ser. X, Vol. V, pt. 2.

[2] Tertiary Freshwater Deposits of Baluchi tan and Sind. *Rec. Geol. Surv. Ind.*, XXXVII, pp. 145, 146 (1908).

[3] Geology of Mari Hill Station, Punjab. *Rec. Geol. Surv. Ind.*, VII, p. 68 1874).

[4] Geology of Hazara. *Mem. Geol. Surv. Ind.*, XXVI, p. 42 (1896).

often contain nummulites of Khirthar age, in some places obviously derived, in others giving a deceptive appearance of being *in situ.* They have yielded, particularly in the neighbourhood of Fatehjang, well preserved remains of *Anthracotherium bugtiense*, *Brachyodus africanus*, *Teleoceras fatehjangense*, a species allied to *T. blanfordi*, and a species of *Hemimeryx.* Two of these species are found in the Nari series of the Bugti Hills and it is impossible to suppose them older than aquitanian. We are therefore able definitely to regard this horizon as Upper Nari. Its conglomerates are unmistakable, and are found overlying the Khirthars throughout the Salt Range as far as the Jhelam river and in the Kohat District across the Indus. In the latter area a ribbed *Unio* occurs in these beds, which may be the same as one of the species found in the Upper Nari of the Bugti Hills. Whether the series exists between the Kohat and Dera Ghazi Khan Districts in the basal beds of what has been mapped as Lower Siwalik, I am uncertain.

## The Murree.

The Murree series is developed to its fullest extent in the Murree Hills. In the Rawal Pindi and Jhelam Districts a gradual transition can be traced from typical purple Murree sandstones into typical concretionary conglomerates with a Lower Siwalik fauna. It is possible to trace the gradual dying out of the Murree series as we go south from the Murree and Kala Chitta Hills, until in the Salt Range it is entirely missing, and the 50 to 100 feet of Upper Nari are overlain unconformably by typical Lower Siwaliks.

The Murree series has yielded no vertebrate fossils, but plant remains, including *Sabal major*, occur at Murree and in the parallel beds of the Kasauli series.

The Dagshai and Kasauli series, as has been clearly recognised, entirely correspond to the Murree series. The purple sandstones of this group are unmistakable, from the Siwalik Hills to the Indus. In the Siwalik Hills, however, the Murree series is faulted against the Nahans (Lower Siwalik) and the Nari series has not been recognised. From its relations to the Upper Nari horizon it is clear that the burdigalian and helvetian stages must cover the period of its deposition.

## The Lower Siwalik.

In the paper[1] previously quoted I have given a palæontological and lithological description of the Lower Siwalik beds of Sind and the Bugti Hills. I have shown that over that large area the curious concretionary conglomerates form one of their most striking features, while *Dinotherium* and *Tetrabelodon angustidens* are constantly present. I then suggested that a representative of them would be found in the Punjab. This has now proved to be the case. Lithologically as well as palæontologically, a portion of the newer Tertiary formation mapped and described by Wynne, Medlicott, Lydekker, Theobald, Middlemiss, and others, corresponds exactly to the Lower Siwaliks of Sind and Baluchistan. Besides the concretionary conglomerates there are calcareous nodular beds and clays, the whole deeply tinted red, and, by the colouration alone, sharply marked off from the overlying Middle Siwaliks. Real pebbles are entirely absent. The fauna is small; but careful search north of the Salt Range has revealed the presence of *Dinotherium indicum*, and *sindiense*, *Tetrabelodon angustidens*, *Microselenodon silistrensis*, *Merycopotamus pusillus*, *Listriodon pentapotamiæ*, and *Hyotherium sindiense*; also a species of *Dryopithecus* allied to *D. rhenanus*, a *Pseudælurus*, and a new Giraffoid genus of a more generalised type than any of those described by Lydekker, to which I have given the name *Giraffokeryx*, and finally representatives of the Creodonta. All these are absent from the overlying beds, from which come the greater number, if not all, of the fossils collected by Theobald in the Potwar. Between Chenji and Kala Kahar in particular these beds contain an abundance of fossils. On Mt. Tilla and on the Bakrala ridge, where they overlie a representative of the Murree series, mammalian remains, though scanty, include the characteristic species *Dinotherium indicum* and *Tetrabelodon angustidens*. *Hipparion* is rare in these beds.

The genus *Dinotherium* has been reported at various places on the right bank of the Indus between Dera Ghazi Khan and Kushalgarh, from beds which are obviously a continuation of the Lower Siwalik outcrop of the Bugti Hills. The horizon at Kushalgarh, referred to in the above mentioned paper[2] and previously

[1] Pilgrim, *ibid*, p. 159.
[2] Pilgrim, *ibid*, p. 163.

mentioned by Lydekker,[1] is essentially Lower Siwalik, the beds being very similar in character to those of the Bugti Hills. Here the following fossils were obtained :—

*Sus hysudricus*, Falc. & Caut.
*Hyotherium sindiense*, Lyd.
*Listriodon pentapotamiæ*, Falc.
*Sanitherium schlagintweitii*, Meyer.
*Merycopotamus pusillus*, Lyd.
*Dorcatherium majus*, Lyd.
*Rhinoceros sp.*
*Hipparion sp.*
*Dinotherium indicum*, Falc. & Caut.
*Amphicyon palæindicus*, Lyd.

It seems certain, too, that the fossil mammalian fauna of Perim Island must be relegated to the same category, as Lydekker has clearly recognized.

The Nahan series of the Siwalik Hills, and its correlation with the Lower Siwaliks of Sind and the Punjab, is dealt with on page 193 of the present paper.

One word as to the geological age of the Lower Siwaliks. In Europe the range of *Tetrabelodon angustidens* is from burdigalian to sarmatian, which gives us convenient age limits for the series of beds containing this species. We have seen that the Murree series extended in continuous deposit from a horizon in the aquitanian (Upper Nari) right into the Lower Siwalik. It seems hardly reasonable to allow more than the burdigalian and helvetian stages for the accumulation of the Murree sediments. Hence it follows that we should place the base of the Lower Siwaliks no later than tortonian. The fossil evidence lends support to this conclusion, for the alliance between the faunas of the Upper Nari and the Lower Siwalik is not a very remote one.

1 Fossil Mammalian Fauna of India. *Rec. Geol. Surv. Ind.*, IX, p. 92 (1876). It will be noticed that *Hyaenodon indicus* Lyd. is omitted from this fauna since I have no doubt that the premolar referred by Lydekker to *Hyaenodon* [Pal. Ind. (10) II p. 349] and subsequently by Schlosser [*Beitr. Pal. Öst.—Ung VI* (1888) p. 195] to *Hyaena* is really the 3rd lower premolar of *Hyotherium sindiense* Lyd. of which numerous specimens occur amongst the rich collections made from the Lower Siwaliks of Chenji. Meyer's *Merycopotamus dissimilis* is I think, *Merycopotamus pusillus*, Lyd. The latter species seems to me to find a more appropriate place in the genus *Hemimeryx*.

## The Middle Siwalik.

North of the Salt Range these Lower Siwa iks pass gradually into a richly fossiliferous series of beds, to which I shall restrict the term Middle Siwalik. These beds manifestly thin out as we go eastward to the Jhelam. Lithologically, they are distinguished with ease from the Lower Siwalik, once we are above the passage beds. They are much softer, very much paler in tint, and pebble beds occur here and there. Since, however, the fossils of the Lower Siwaliks, occur near the base of that series and those of the Middle Siwaliks a considerable distance above the passage beds, it is not surprising that the two faunas should be perfectly different. There is actually a vertical distance of some 6,000 feet between these two fossiliferous zones. *Dinotherium* and *Tetrabelodon angustidens* have been replaced by *Mastodon punjabiensis* and *Stegodon*. *Hipparion* and large antelopes abound, and amongst the Giraffoids *Helladotherium* and *Hydaspitherium* have succeeded the more primitive *Giraffokeryx* and *Bramatherium*. The fauna is of a similar type to that of Pikermi and Samos, except in the absence of *Dinotherium*,[1] and a pontian age may undoubtedly be assigned to these beds.

## The Upper Siwalik.

An equally gradual transition occurs from the Middle Siwaliks into the still higher beds, seen near Rhotas and at Darapur. These are indistinguishable in character from the strata exposed in the Siwalik Hills, and included by Middlemiss[2] in his Siwalik conglomerate and Sand-rock stages. They consist of grey sandstones, often very coarse and for the most part exceedingly soft and friable, alternating, especially in their upper portion, with conglomerates and boulder beds. Pink clays occasionally intervene. The Siwalik Hill fauna of the Fauna Antiqua Sivalensis is repeated identically in these beds, though not in such varied abundance. The fauna is quite distinct from that of the Middle Siwaliks and there is remarkably little overlapping of species. The beds form an easily recognisable series and may be known as Upper Siwalik. They can be traced in an almost continuous outcrop, by their lithological character and by

[1] A recent find of two *Dinotherium* teeth supposed to come from the Middle Siwaliks of Nila, north of the Salt Range, suggests that this genus may not have become altogether extinct in India in Middle Siwalik times.

[2] Geology of Sub-Himalaya of Garhwal and Kumaun. *Mem. Geol. Surv. Ind.*, XXIV (1891).

their fossil contents, from the Salt Range through the Pabbi Hills into Jammu and Kangra and thence into the Siwalik Hills.

*Equus*, *Bos*, *Elephas*, *Camelus*, and the Giraffoid genus *Sivatherium* characterise this division, these genera being found everywhere in these beds throughout India.

At various localities throughout the Potwar, in the Murree Hills, at Makhad and neighbouring places on the Attock bank of the Indus, near Domeli on the southern side of the Bakrala ridge and at Nammal, north of the Salt Range, we find highly tilted sands and conglomerates resting on the upturned and denuded surface of both Lower and Middle Swaliks. Thus these beds must be newer than the fossiliferous sandstones which succeed the Middle Siwaliks conformably. They are unfortunately almost unfossiliferous, but a metatarsal of *Sivatherium* from the conglomerate near Makhad inclines one to the opinion that all of these beds are probably uppermost Siwalik.

The Upper Siwaliks may be regarded as Pliocene.

Since a thickness of 10,000 feet must be allowed for this part of the series, in its area of maximum development, and since the highest beds at Bubhor contain *Equus namadicus* and *Buffelus palæindicus*, which are Pleistocene forms, it is probable that the series reaches almost, if not quite, to the top of the Pliocene.

Thus, the whole Siwalik series is very conspicuously developed in the Salt Range area and is fossiliferous throughout, in striking contrast to what is the case in the Siwalik Hills. It has been shown above that it is easy to trace the stratigraphical connection between this series and the underlying Murree and Upper Nari series developed either in the same or in adjoining areas. It therefore seems inevitable that we should adopt this as our type area, and correlate the freshwater deposits found in other parts of India with different parts of the Salt Range system, according as we may be guided by fossil or lithological evidence or stratigraphical considerations. I do not intend this to make any alteration in the existing nomenclature, but as from time to time fresh areas are re-mapped or re-examined, the boundaries and names of the formations may, it is hoped, become definite and significant, instead of loose and meaningless as is the case at present.

## The Freshwater Deposits of the Siwalik Hills.

My travels in the Siwalik Hills, unfortunately, added but few specimens to my collection and convinced me that there is little

hope in the future of obtaining more. As compensation, however, I was able to visit many of the fossil localities of the old discoverers and have ascertained the important fact that most of them occur near the top of the series, and none of them very far down. The fossils are too fragile to have been carried very far from the beds in which they were deposited and there could have been no collection from talus heaps containing the debris of strata widely different from one another in age. It is, therefore, absolutely certain that the fauna of these beds is considerably newer than the Middle Siwalik fauna and the same strata from which the remains of *Camelus sivalensis* and *C. antiquus* were exhumed, yielded also *Equus, Sivatherium, Sus, Elephas, Stegodon, Mastodon, Chalicotherium,* and *Giraffa.* I am even doubtful whether a single one of the recorded species can be assigned to the same horizon as the Middle Siwaliks of the Punjab, and, failing exact information to the contrary, I prefer, with one exception, to class the whole fauna as Upper Siwalik. This exception relates to the fossils occurring in the very lowest beds bordering the plain, whence, in the Kalawala Rao, Cautley obtained some fossils, of which, whether the others were lost or not, the sole existing remnant, so far as I am aware, are the ones figured in Plate III of Royle's Himalayan Botany.[1] Lydekker refers the milk tooth doubtfully to *Anthracotherium* (*Microselenodon*) *silistrense*. Cautley found the same bed, a characteristic concretionary clay conglomerate, also on the north side of Nahan and obtained fossils of the same type from it. All trace of these is lost. I, however, re-discovered the bed north of Nahan, though I found no fossils in it. Now I am advancing no new theory, when I refer the Nahan beds to the same horizon as the Lower Siwaliks of Sind,[2] I would only say that although the lithological resemblance as a whole is not very close, the concretionary clay conglomerate does undoubtedly resemble similar beds from the Lower Siwaliks of the Punjab, while nothing of the sort is known from the Middle Siwaliks. *Anthracotherium* (*Microselenodon*) *silistrense* is an ancient type and there seems to be evidence from a specimen formerly in the Rurki museum that a *Dinotherium* tooth was obtained from the base of these hills. Further, the specimen of *Progiraffa sivalensis* which is reported to have come from the hills near Rurki is identical with other specimens obtained

1 Royle: Illustrations of the Botany and Other Branches of the Natural History of the Himalayan Mountains. Introduction, p. xxx (1839).

2 Manual of the Geology of India, 2nd edition (1893), pp. 357, 364.

from the Lower Siwaliks of Chenji in the Salt Range. For these reasons I would dissent from R. D. Oldham,[1] who places this bed in the so-called "Middle Siwaliks" and considers the occurence north of Nahan as a "Middle Siwalik" outlier. I think the bed is more appropriately placed with the Lower Siwaliks and considered as forming part of the Nahan series. Mr. Middlemiss has mapped as Nahan, beds which probably occupy a very similar stratigraphical position, to the east of the Ganges.[2] I am not prepared to dispute Middlemiss' assertion that we have an absolutely conformable series in the Siwalik hills from the Nahan beds upward. I would only suggest, as evidence has shown to be the case elsewhere, that the Middle Siwalik period here was characterised by remarkably slow deposition, so that probably a few hundred feet represents the entire thickness of strata which correspond to the Middle Siwaliks of the Punjab. The lithological character of the whole series in the Siwalik Hills above the Kalawala Rao beds is identical with that of the Upper Siwaliks of the Pabbi Hills, while the vertical thickness of the former set of beds only slightly exceeds that of the latter. This lends additional support to the above view.

## Geological History of the Deposits.

In conclusion, I may say that I am on the whole in complete accord with the view expressed by Theobald[3] and Middlemiss[4] as to the general conformability of all these freshwater beds. In fact, speaking broadly, it seems certain that from the Nari to the top of the Siwaliks we have a continuous series of deposits, by which I mean that at no portion of the great period covered by these various deposits was sedimentation altogether interrupted. It is however possible, by correlating the faulting and the thinning out or disappearance of beds in different places, to arrive at the certain conclusion that at six distinct periods earth movements were especially prevalent, and as a result alteration to a greater or less extent took place in the configuration of the land surface, and consequently in the depositing area of the great rivers. These periods of orogenic intensity were as follows :—

1. At the close of Nari times. This is shown by the marine

[1] R. D. Oldham: *Rec. Geol. Surv. Ind.*, XVII, p. 79 (1884).

[2] Middlemiss: Geology of Sub-Himalaya of Garhwal and Kumaon. *Mem. Geol. Surv. Ind.*, XXIV (1891).

[3] Theobald: Siwalik series. *Rec. Geol. Surv. Ind.*, XIV, p. 108 (1881).

[4] Middlemiss: *Ibid*, pp. 29, 124 (1891).

transgression which occurred in Sind and deposited the Gaj limestones on the freshwater grits of the Upper Nari. Further north, in the Bugti Hills and the Salt Range, it seems to have checked deposit altogether, because we find the Lower Siwaliks resting on the Nari. Still further north we have sedimentation again and increasing in quantity, until in the Murree series we find freshwater deposits representing not only the Gaj limestones, but also a later period when marine deposition in Sind had ceased. We have therefore in the Rawal Pindi area a continuous river sedimentation corresponding to the continuous series of marine deposits which Vredenburg has shown to exist in Makran from Nari times upward, and which, as the present writer has found, are identically repeated in Persia, extending from aquitanian up to tortonian or sarmatian.

2. The next movements are indicated by the removal of marine conditions in Sind and by the change in the character of the deposit from the Dagshai to the Kasauli series in the sub-Himalayan region.

3. In the tortonian period movements occurred which terminated the great break, which exists from Sind as far as the Salt Range between either Nari or Gaj and Lower Siwalik.

4. At the close of Lower Siwalik times interruption of deposit again occurred, because in the Bugti Hills at all events, and probably in other parts of India as well, the Middle Siwaliks are absent. East of the Jhelam they are probably only feebly represented. On the other hand, between the Jhelam and the Indus, there was a thick deposit of Middle Siwaliks, which passes directly upward into the Upper Siwaliks.

5. It is, however, certain that in many places intense movements followed, and that upheaval and denudation of the Middle Siwaliks occurred, because of the fact that in many places in the Salt Range area (see page 192) highly tilted conglomerates of probably uppermost Siwalik age lie quite unconformably on Middle Siwalik beds.

6. Later than all these disturbances came the last orogenic period which tilted the Upper Siwaliks into the position in which we find them today.

Briefly summarised, the two preceding pages express that at six stages during the deposition of the newer tertiaries of India, earth movements intervened such as to alter the depositing areas of the rivers of that time, producing sedimentation in areas which had

been outside the limits of the deposit, diminishing it in areas where it had been rapid, quickening it in areas where it had been slow, interrupting it altogether; or finally submerging tracts of country and so effecting a replacement of fluviatile by marine deposits.

## The Upper Tertiaries of Burma.

As far as Burma is concerned, our stratigraphical knowledge of the newer Tertiaries still leaves much to be desired.

It seems certain, however, that from the lowest beds of the Irrawaddy series at Yenangyaung both Noetling and Grimes collected a distinctive vertebrate fauna, which I have examined and in which I have recognised the following species:—

*Mastodon latidens*, Clift.
*Aceratherium lydekkeri*, Pilg.
*Hipparion punjabiense*, Lyd.
*Merycopotamus dissimilis*, F. & C.
*Tetraconodon minor*, Pilg.
*Hippopotamus iravaticus*, F. & C.
*Taurotragus latidens*, Lyd.
*Cervus sp.*

To this must no doubt be added *Stegodon clifti* and the fossils obtained by Clift at Yenangyaung and also the *Vishnutherium* mandible collected by W. T. Blanford.

This is a typical Middle Siwalik fauna, that is to say it is older than that of the Siwalik Hills and newer than that of the Lower Siwaliks of Sind, the Bugti Hills and the Salt Range. We may therefore with certainty assign the lowest beds of the Irrawaddy series at Yenangyaung to the Middle Siwalik.

The boundary between these beds and the underlying marine Pegu series is in Upper Burma almost always a well marked one. At Yenangyaung an estuarine zone occurs some 1,200 feet below the base of the Irawaddy series. From this Dr. Noetling obtained the upper molar of a small Tragulid and the last lower molar of *Dorcatherium* sp., both of them erroneously referred by him to *Anoplotherium*.[1] It is unlikely that these are older than Lower Siwalik. Lately Mr.

[1] Noetling. Fauna of the Miocene Beds of Burma: *Pal. Ind.*, New series I, p. 378, Pl. XXV, figs. 24, 25.

Cunningham Craig has obtained from Maingyaung in the Pakokku district, which is probably at a horizon only slightly lower than that of Noetling's mammalian teeth, a small lower molar allied to ***Telmatodon*** which may belong to the same species as an upper molar from the Lower Siwaliks of Sind.[1] Assuming the correctness of the age attributed to these fossils it follows that the Lower Siwalik period in Upper Burma is characterized by marine or estuarine deposits. Moreover, there cannot be any large or widespread unconformity between the top of the Pegu series (Lower Siwalik) and the base of the Irawaddy series (Middle Siwalik).

Mr. Murray Stuart,[2] however, has lately established the existence in the Prome area in Lower Burma of a marked unconformity in beds hitherto assigned to the Pegu series. He adduces evidence to prove that the beds below the break are of no later than helvetian age.[3] The beds above the break (Mogaung sands) are marine passing into estuarine and finally into the fluviatile beds of the Irawaddy series. Since the publication of the above paper Mr. Stuart has obtained from these beds an abundance of more than one species of ***Ostrea*** as well as other mollusca, which occur in the Pegu series in Upper Burma. He is, therefore, inclined to regard the "Mogaung sands" as equivalent to the upper 1,200 feet of the Pegu series at Yenangyaung and so of Lower Siwalik or tortonian age. The absence of distinctive vertebrate fossils both from the Mogaung grits as well as from the Irawaddy beds of this area renders, however, the precise age of the beds succeeding the unconformity very doubtful. The Irawaddy series in Pakokku is, according to Sub-Assistant Sethu Rama Rao, some 8,000 feet thick. No distinctive fossils are known from its upper beds, but, no doubt, they are, in part at any rate, Upper Siwalik. It seems probable that some of the so-called "Plateau gravel" is also Upper Siwalik, since I am informed by Mr. Stuart and Mr. Cunningham Craig that these gravels have often a very considerable dip. From Kyaukwet in the Pakokku district Mr. Lister James has obtained some tooth fragments referable to *Cadurcotherium*, which point to a still lower estuarine zone in the aquitanian.

It only remains now to express in tabular form the subject matter of the preceding pages. This is done in the table on page 205, which will, I hope, render my explanation clearer.

[1] Pilgrim: *Rec. Geol. Surv. Ind.*, XL. pt. 1 p. 68.

[2] Stuart: *Rec. Geol. Surv. Ind.*, XXXVIII, Pt. 4, p. 266 (1910).

[3] Stuart: *ibid.*, p. 274.

On this page and the following will be found a revised list of the Tertiary Mammalia of India, to each species being added the main localities in which it has been found and its geological horizon. I do not think there are many of the species, whose stratigraphical position is open to doubt. It is, however, possible that later discoveries may on the one hand modify our present ideas on the range of certain species and on the other conduce to the separation of forms now classed as one.

Fresh discoveries have necessitated numerous alterations in the nomenclature of genera and species since the latest allusion to them in the publications of the Geological Survey of India. These have, as a rule, been adopted without comment, but I have lately published[1] brief preliminary notes on new species or changes for which I am myself responsible, to which reference can be made if desired.

## Tertiary Mammalian Fauna of India.

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| PRIMATES. | | | | | |
| Simia sp. cf. satyrus Linn. . | Siwalik Hills . . . | — | — | — | + |
| Sivapithecus indicus, Pilgrim | Alipur (Punjab) . . | — | + | — | — |
| Anthropopithecus sivalensis, Lyd. | Jabi . . . . . | — | — | + | — |
| Dryopithecus punjabicus, Pilg. | Chenji (Salt Range) . . | — | + | — | — |
| Semnopithecus palæindicus, Lyd. | Siwalik Hills . . . | — | — | — | + |
| Semnopithecus asnoti, Pilg. | Asnot . . . . . | — | — | + | — |
| Macacus sivalensis, Lyd. . | Asnot . . . . . | — | — | + | — |
| Papio sub-himalayanus, H. Meyer. | Siwalik Hills . . . | — | — | — | + |
| Papio falconeri, Lyd. . | Siwalik Hills . . . | — | — | — | + |
| CARNIVORA. | | | | | |
| Dissopsalis carnifex, Pilg. . | Chenji and Kotal Kund (Salt Range) . . . | — | + | — | — |
| Dissopsalis ruber, Pilg. . | Chenji (Salt Range) . . | — | + | — | — |
| Pterodon bugtiensis, Pilg. . | Bugti Hills . . . . | + | — | — | — |
| Pterodon sp., Pilg. . . | Bugti Hills . . . . | + | — | — | — |
| Hyænarctos palæindicus, Lyd. | Jabi | — | — | + | — |

[1] Pilgrim: Notices of New Mammalian Genera and Species from the Tertiaries of India. *Rec. Geol. Surv. Ind.*, XL, Pt. I, p. 63 (1910).

## Tertiary Mammalian Fauna of India—*contd.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| CARNIVORA—*contd.* | | | | | |
| Hyænarctos punjabiensis, Lyd. | Asnot . . . . . | — | — | + | — |
| Hyænarctos sivalensis, F. & C. | Siwalik Hills . . . | — | — | — | + |
| Melursus theobaldi, Lyd. . | Kangra . . . . . | — | — | — | + |
| Mellivorodon palæindicus, Lyd. | Asnot ; Niki . . . | — | — | + | — |
| Mellivora punjabiensis, Lyd. | Asnot . . . . . | — | — | + | — |
| Mellivora sivalensis, F. & C. | Moginand (Siwalik Hills) . | — | — | — | + |
| Mustela sp., Lyd. . . | Siwalik Hills . . . | — | — | — | + |
| Enhydriodon sivalensis, F. & C. | Siwalik Hills . . . | — | — | — | + |
| Lutra palæindica, F. & C. . | Siwalik Hills . . . | — | — | — | + |
| Lutra bathygnathus, Lyd. . | Punjab . . . . | — | — | + | — |
| Amphicyon cf. major, Blainv | Bugti Hills . . . | + | — | — | — |
| Amphicyon palæindicus, Lyd. | Kushalgarh; Sind; Chenji? Nurpur. | — | + | — | — |
| Amphicyon lydekkeri, Pilg. | Asnot . . . . . | — | — | + | — |
| Cephalogale shahbazi, Pilg. | Bugti Hills . . . | + | — | — | — |
| Canis cautleyi, Bose . . | Siwalik Hills . . . | — | — | — | + |
| Vulpes curvipalata, Bose . | Moginand (Siwalik Hills) . | — | — | — | + |
| Hyæna felina, Bose . . | Siwalik Hills ; Jamu . | — | — | — | + |
| Hyæna colvini, Lyd. | Siwalik Hills ; Kangra | — | — | — | + |
| Hyæna sivalensis, Bose . | Siwalik Hills . . . | — | — | — | + |
| Lycyæna macrostoma, Lyd. | Jabi ; Dhok Pathán ; Asnot | — | — | + | — |
| Lepthyæna sivalensis, Lyd. | Asnot ; Dhok Pathán . | — | — | + | — |
| Palhyæna proava, Pilg. . | Chenji (Salt Range) . | — | + | — | — |
| Palhyæna indica, Pilg. . | Asnot . . . . . | — | — | + | — |
| Palhyæna sp., Pilg. . . | Asnot . . . . . | — | — | + | — |
| Viverra bakeri, Bose . . | Siwalik Hills . . . | — | — | — | + |
| Viverra durandi, Lyd. . | Siwalik Hills . . . | — | — | — | + |
| Aeluríctis sivalensis, Lyd. . | Punjab . . . . . | — | — | + | — |
| Aeluropsis annectans, Lyd. . | Asnot . . . . . | — | — | + | — |
| Machærodus sp., Pilg. . | Chenji (Salt Range) . | — | + | — | — |
| Machærodus sp., Lyd. . | Asnot . . . . . | — | — | + | — |
| Machærodus sivalensis, F. & C. | Siwalik Hills ; Hoshiarpur | — | — | — | + |
| Machærodus palæindicus, Bose. | Siwalik Hills . . . | — | — | — | + |
| Cynælurus brachygnathus, Lyd. | Siwalik Hills . . . | — | — | — | + |
| Felis cristata, F. & C. . | Siwalik Hills . . . | — | — | — | + |
| Felis subhimalayana, Bronn. | Siwalik Hills . . . | — | — | — | + |
| Felis sp., Lyd. . . . | Jabi (Punjab) . . . | — | — | + | — |
| Felis sp., Pilg. . . . | Bhyta (Punjab) . . | — | — | + | — |
| RODENTIA. | | | | | |
| Nesokia sp. cf. hardwickii, Gray. | Siwalik Hills . . . | — | — | — | + |
| Rhizomys sivalensis, Lyd. | Jabi . . . . . | — | — | + | — |
| Rhizomys sp., Lyd. . . | Siwalik Hills . . . | — | — | — | + |

## Tertiary Mammalian Fauna of India—*contd.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| **RODENTIA**—*contd.* | | | | | |
| Hystrix sp., Lyd. | Moginand (Siwalik Hills) | — | — | — | + |
| Hystrix sivalensis, Lyd. | Asnot | — | — | + | — |
| Caprolagus sivalensis, Major | Siwalik Hills | — | — | — | + |
| **PROBOSCIDEA.** | | | | | |
| Dinotherium indicum, Falc. | Sind; Bugti Hills; Kushalgarh; Dera Ghazi Khan; Chenji; Siwalik Hills | — | + | — | — |
| Dinotherium indicum, Falc. var. naricum, Pilg. | Bugti Hills | + | — | — | — |
| Dinotherium sindiense, Lyd. | Sind; Mari (Kohat); Chenji | — | + | — | — |
| Mœritherium (?) sp., Pilg. | Bugti Hills | + | — | — | — |
| Tetrabelodon crepusculi, Pilg. | Bugti Hills | + | — | — | — |
| Tetrabelodon angustidens, Cuv. | Bugti Hills; Bakrala Ridge; Chenji | — | + | — | — |
| Tetrabelodon pandionis, Falc. | Asnot; Niki; Sind; Perim I.; Bugti Hills. | — | + | + | — |
| Tetrabelodon falconeri, Lyd. | Sind; Asnot | — | + | + | — |
| Mastodon perimensis, F. & C. | Perim I.; Sind | — | + | — | — |
| Mastodon cautleyi, Lyd. | Perim I. | — | + | — | — |
| Mastodon sivalensis, F. & C. | Lehri: Kangra; Hoshiarpur; Siwalik Hills. | — | — | — | + |
| Mastodon latidens, Clift | Asnot; Yenangyaung (Burma). | — | — | + | — |
| Mastodon punjabiensis, Lyd. | Niki; Asnot; Dhok Pathán | — | — | + | — |
| Stegodon clifti, Falc. | Siwalik Hills; Asnot; Yenangyaung (Burma). | — | — | + | + |
| Stegodon bombifrons, F. & C. | Siwalik Hills; Asnot; Niki | — | — | + | + |
| Stegodon ganesa, F. & C. | Lehri: Hoshiarpur; Siwalik Hills; Pabbi Hills | — | — | | + |
| Stegodon insignis, F. & C. | Lehri; Hoshiarpur; Siwalik Hills. | — | — | — | + |
| Elephas planifrons, F. & C. | Lehri; Kangra; Pinjor; Siwalik Hills. | — | — | — | + |
| Elephas hysudricus, F. & C. | Hoshiarpur; Kangra; Siwalik Hills; Pabbi Hills | — | — | — | + |
| **PERISSODACTYLA.** | | | | | |
| Cadurcotherium indicum, Pilg. | Bugti Hills | + | — | — | — |
| Aceratherium bugtiense, Pilg. | Bugti Hills | + | — | — | — |
| Aceratherium lydekkeri, Pilg. | Asnot; Burma; Niki; Jabi | — | — | + | — |
| Aceratherium perimense, Falc. | Perim I.; Sind; Dhariala (Salt Range). | — | + | — | — |
| Aceratherium gajense, Pilg. | Sind (Gaj series); Bugti Hills | + | — | — | — |
| Aceratherium gajense var. intermedium, Lyd. | Sind | — | + | — | — |
| Diceratherium shahbazi, Pilg. | Bugti Hills | + | — | — | — |

## Tertiary Mammalian Fauna of India—*contd.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik | Upper Siwalik. |
|---|---|---|---|---|---|
| PERISSODACTYLA—*contd.* | | | | | |
| Diceratherium naricum, Pilg. | Bugti Hills . . . . | + | — | — | — |
| Teleoceras blanfordi, Lyd. . | Bugti Hills . . . . | + | — | — | — |
| Teleoceras blanfordi, Lyd. var. mihi. | Niki . . . . . | — | — | + | — |
| Teleoceras fatehjangense, Pilg. | Ajurwala (Kala Chitta Hills) | + | — | — | — |
| Dicerorhinus platyrhinus, F. & C. | Siwalik Hills ; Pabbi Hills | — | — | — | + |
| Rhinoceros sivalensis, F. & C. . | Siwalik Hills ; Asnot ; Dhok Pathán ; Burma | — | — | + | + |
| Rhinoceros palæindicus, F. & C. | Siwalik Hills ; Asnot ? . | — | — | ? | + |
| Hipparion perimense, Pilg. | Perim I . . . . . | — | + | — | — |
| Hipparion feddeni, Lyd. . | Perim I. . . . . . | — | + | — | — |
| Hipparion theobaldi, Lyd. | Kaipar ; Niki ; Dhok Pathán. | — | — | + | — |
| Hipparion punjabiense, Lyd. | Niki ; Dhok Pathán . . | — | — | + | — |
| Hippodactylus antilopinus, F. & C. | Siwalik Hills . . . | — | — | — | + |
| Hippodactylus chisholmi, Pilg. | Dhok Pathán . . . | — | — | + | — |
| Equus sivalensis, F. & C. . | Siwalik Hills ; Rupar ; Lehri ; Pabbi Hills. | — | — | — | + |
| Equus namadicus, F. & C . | Hoshiarpur ; Kangra . | — | — | — | + |
| ANCYLOPODA. | | | | | |
| Phyllotillon naricus, Pilg. . | Bugti Hills . . . . | + | — | — | — |
| Schizotherium (?) sp. . . | Bugti Hills . . . . | + | — | — | — |
| Chalicotherium (?) sindiense, Lyd. | Sind ; Bakrala Ridge ; Chenji | — | + | — | — |
| Chalicotherium (?) sp. . | Tatrot . . . . . | — | — | + | — |
| Chalicotherium sivalense, F. & C. | Siwalik Hills . . . | — | — | — | + |
| ARTIODACTYLA. | | | | | |
| Anthracotherium bugtiense, Pilg. | Bugti Hills ; Ajurwala (Kala Chitta Hills). | + | — | — | — |
| Anthracotherium (Microselenodon) mus, Pilg. | Bugti Hills . . . . | + | — | — | — |
| Anthracotherium (Microselenodon) silistrense, Pent. | Sind, Asnot (?); Garo Hills; Chenji; Siwalik Hills. | — | + | — | — |
| Ancodus ramsayi, Pilg. . | Bugti Hills . . . | + | — | — | — |
| Brachyodus hyopotamides, Lyd. | Bugti Hills . . | + | — | — | — |
| Brachyodus giganteus, Lyd. | Bugti Hills . . . | + | — | — | — |

## Tertiary Mammalian Fauna of India—*contd.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| ARTIODACTYLA—*contd.* | | | | | |
| Brachyodus africanus, Andr. | Bugti Hills; Ajurwala (Kala Chitta Hills) | + | — | — | — |
| Merycops longidentatus, Pilg. | Bugti Hills . . . | + | — | — | — |
| Hyoboops palæindicus, Lyd. | Sind . . . . | — | + | — | — |
| Hyoboops naricus, Pilg. . | Bugti Hills . . . | + | | | |
| Merycopotamus dissimilis, F. & C. | Asnot; Siwalik Hills; Bhimber. | — | — | + | + |
| Merycopotamus nanus, F. & C. | Asnot; Siwalik Hills . | — | — | + | + |
| Hemimeryx speciosus, Pilg.. | Bugti Hills . . . | + | — | — | — |
| Hemimeryx blanfordi, Lyd. | Sind . . . . | — | + | — | — |
| Hemimeryx pusillus, Lyd. . | Kushalgarh; Chenji; Perim I; Sind. | — | + | — | — |
| Telmatodon bugtiensis, Pilg. | Bugti Hills . . . | + | — | — | — |
| Telmatodon (?) sp., Pilg. . | Pakokku (Burma); Sind . | — | + | — | — |
| Gonotelma shahbazi, Pilg. . | Bugti Hills . . . | + | — | — | — |
| Chæromeryx silistrensis, Pent. | Garo Hills; Sind . . | — | + | — | — |
| Chæromeryx sp. mihi . . | Asnot . . . . | — | — | + | — |
| Tetraconodon magnus, Lyd. non Falc. | Asnot . . . . | — | — | + | — |
| Tetraconodon minor, Pilg. | Yenangyaung (Burma) . | — | — | + | — |
| Bugtitherium grandincisivum, Pilg. | Bugti Hills . . . | + | — | — | — |
| Palæochœrus affinis, Pilg. | Bugti Hills . . . | + | — | — | — |
| Palæochœrus perimensis, Lyd. | Perim I. . . . . | — | + | — | — |
| Hyotherium sindiense, Lyd. | Sind; Chenji (Salt Range); Kushalgarh. | — | + | — | — |
| Listriodon pentapotamiæ, Falc. | Kushalgarh; Sind; Niki; Chenji . . . | — | + | ? | — |
| Listriodon theobaldi, Lyd. | Jabi; Chenji . . . | — | + | + | — |
| Hippohyus sivalensis, F. & C. | Siwalik Hills . . . | — | — | + | + |
| Hippohyus lydekkeri, Pilg. . | Asnot . . . . | — | — | + | — |
| Sus hysudricus, F. & C. . | Sind; Kushalgarh; Asnot; Siwalik Hills; Chenji . | — | + | + | + |
| Sus falconeri, Lyd. . . | Siwalik Hills . . . | — | — | — | + |
| Sus punjabiensis, Lyd. . | Asnot . . . . | — | — | + | — |
| Sanitherium schlagintweitii, Meyer. | Kushalgarh . . . | — | + | — | — |
| Potamochœrus titan, Lyd. . | Asnot; Niki . . | — | — | + | — |
| Potamochœrus hysudricus, F. & C. | Siwalik Hills; Asnot . | — | — | + | + |
| Potamochœrus giganteus, F. & C. | Siwalik Hills . . . | — | — | — | + |
| Potamochœrus magnus, F. & C. | Siwalik Hills . . . | — | — | — | + |
| Potamochœrus sp., Lyd. . | Asnot . . . . | — | — | + | — |
| Hippopotamus sivalensis, F. & C. | Siwalik Hills . . . | — | — | — | + |

## Tertiary Mammalian Fauna of India—*contd.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| ARTIODACTYLA—*contd.* | | | | | |
| Hippopotamus sivalensis, F. & C. var. angustidens, Lyd. | Asnot; Dhok Pathán | — | — | + | + |
| Hippopotamus iravaticus, F. & C. | Yenangyaung (Burma); Asnot. | — | — | + | — |
| Camelus sivalensis, F. & C. | Siwalik Hills; Hoshiarpur; Rupar; Kangra; Madanpur; Lehri. | — | — | — | + |
| Camelus antiquus, Lyd. | Moginand (Siwalik Hills) | — | — | — | + |
| Prodremotherium beatrix, Pilg. | Bugti Hills | + | — | — | — |
| Gelocus naricus, Pilg. | Bugti Hills | + | — | — | — |
| Dorcabune anthracotheroides, Pilg. | Chenji and Kotal Kund (Salt Range); Sind. | — | + | — | — |
| Dorcatherium birmanicum, Noetling. | Yenangyaung (Burma, Pegu series). | — | + | — | — |
| Dorcatherium majus, Lyd. | Kushalgarh; Sind; Chenji (Salt Range); Asnot. | — | + | + | — |
| Dorcatherium minus, Lyd. | Pohta; Asnot; Chenji | — | + | + | — |
| Tragulus sivalensis, Lyd. | Asnot | — | — | + | — |
| Progiraffa exigua, Pilg. | Bugti Hills | + | — | — | — |
| Progiraffa sp., Pilg. | Sind | — | + | — | — |
| Progiraffa sivalensis, Lyd. | Siwalik Hills; Chenji (Salt Range). | — | + | — | — |
| Giraffa sp., Falc. | Perim I.; Chenji (Salt Range). | — | + | — | — |
| Giraffa punjabiensis, Pilg. | Asnot | — | — | + | — |
| Giraffa sivalensis, F. & C. | Siwalik Hills | — | — | — | + |
| Vishnutherium iravaticum, Lyd. | Burma; Asnot | — | — | + | — |
| Giraffokeryx punjabiensis, Pilg. | Chenji and Phadial (Salt Range) | — | + | — | — |
| Helladotherium grande, Lyd. | Asnot; Dhok Pathán | — | — | + | — |
| Indratherium majori, Pilg. | Markanda (Siwalik Hills) | — | — | — | + |
| Bramatherium perimense, Falc. | Perim I. | — | + | — | — |
| Hydaspitherium magnum, Pilg. | Asnot | — | — | + | — |
| Hydaspitherium megacephalum, Lyd. | Asnot; Niki | — | — | + | — |
| Hydaspitherium birmanicum, Pilg. | Singu (Burma) | — | — | + | — |
| Sivatherium giganteum, F. & C. | Siwalik Hills; Kangra; Pabbi Hills; Makhad. | — | — | — | + |
| Moschus sp., Lyd. | Punjab | — | — | + | — |
| Cervus sivalensis, Lyd. | Siwalik Hills; Tatrot | — | — | — | + |
| Cervus simplicidens, Lyd. | Asnot; Dhok Pathán | — | — | + | — |
| Cervus triplidens, Lyd. | Punjab | — | — | + | — |
| Bubalus palaeindicus, Falc. | Siwalik Hills | — | — | — | + |

## Tertiary Mammalian Fauna of India—*concld.*

| | Localities. | Nari. | Lower Siwalik. | Middle Siwalik. | Upper Siwalik. |
|---|---|---|---|---|---|
| ARTIODACTYLA—*contd.* | | | | | |
| Tetraceros daviesi, Lyd. | Siwalik Hills | — | — | — | + |
| Cobus patulicornis, Lyd. | Siwalik Hills; Hoshiarpur | — | — | — | + |
| Cobus palæindicus, Lyd. | Siwalik Hills | — | — | — | + |
| Cobus gyricornis, Falc. | Siwalik Hills | — | — | — | + |
| Gazella porrecticornis, Lyd. | Asnot | — | — | + | — |
| Hippotragus sivalensis, Lyd. | Siwalik Hills; Kangra | — | — | — | + |
| Boselaphus lydekkeri. Pilg. | Asnot | — | — | + | — |
| Boselaphus sp. cf. namadicus, Rüt. | Siwalik Hills; Kangra | — | — | — | + |
| Strepsiceros (?) falconeri, Lyd. | Perim I. | — | + | — | — |
| Taurotragus latidens, Lyd. | Asnot; Yenangyaung (Burma); Nila. | — | — | + | — |
| Tragocerus perimensis, Lyd. | Perim I. | — | + | — | — |
| Tragocerus punjabicus, Pilg. | Dhok Pathán; Asnot | — | — | + | — |
| Hemitragus sivalensis, Lyd. | Siwalik Hills | — | — | — | + |
| Bucapra daviesi, Rüt. | Siwalik Hills | — | — | — | + |
| Anoa sp., Pilg. | Asnot | — | — | + | — |
| Anoa triquetricornis, Rüt. | Siwalik Hills | — | — | — | + |
| Anoa antilopinus, F. & C. | Ganawa Khal (Siwalik Hills); Kangra. | — | — | — | + |
| Amphibos acuticornis, Rüt. | Siwalik Hills | — | — | — | + |
| Buffelus palæindicus, Falc. | Bubhor; Jamu | — | — | — | + |
| Buffelus platyceros, Lyd. | Sutor (Kangra); Pabbi Hills. | — | — | — | + |
| Leptobos falconeri, Rüt. | Siwalik Hills | — | — | — | + |
| Bison sivalensis, Lyd. | Pinjor (Siwalik Hills) | — | — | — | + |
| Bos acutifrons, Lyd. | Kangra | — | — | — | + |
| Bos planifrons, Lyd. | Kangra | — | — | — | + |
| Bos platyrhinus, Lyd. | Kangra; Umb | — | — | — | + |

| Europe. | Persia and Makran. | Kángra. | Siwalik Hills. | Burma. |
| --- | --- | --- | --- | --- |
| Pliocene . | Fluviatile deposits of Siv and Bakhtiyári series. (Horizon uncertain | *Equus siva- m giganteum; us; Buffelus* sp. various. | Upper Siwaliks *Camelus sivalensis; Equus sivalensis; Sivatherium giganteum; Elephas hysudricus; Potamochœrus giganteus; Hippodactylus antilopinus. Bos.* sp. various. | Fluviatile deposits of t upper portion of the Irr waddy series; tilte "Plateau gravels" (hoi zon uncertain). |
| Pontian . | | *megacephalum* | Deposition scanty | Lowest beds of the Ir waddy series. (Middle Siwaliks) *Mastodon latidens; Hipparion punjabiense; Tetraconodon min Taurotragus latidens.* |
| Sarmatian . | | | | |
| Tortonian . | Continuous series of ma beds from Stampian wards to an unconfor which is at the Torto in Northern Persia an Southern Persia later. | ) *pus; Dinothe-* nerous plant | Nahan series (Lower Siwaliks) *Microselenodon silistrensis; Dinotherium indicum; Progiraffa sivalensis.* | Pegu series Marine conditions downwa at least to Stampian. E tuarine beds with *Dore therium birmanicum* 1,2 feet below the top. Loc unconformities at mo than one horizon. |
| Helvetian . | | | | |
| Burdigalian | Zone of *Ostrea latimarg*i Vred. | | Dagshai series | Zone of *Ostrea latimargina* Vred. |
| Aquitanian | | ent or if | Upper Nari Apparently absent or if present marine. | Estuarine beds Zone of *Cadurcotheriu indicum.* |
| Stampian . | | nt. | Lower Nari Apparently absent. | |

# A REVISION OF THE SILURIAN-TRIAS SEQUENCE IN KASHMIR. BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 28 to 39.)

## TABLE OF CONTENTS.



## INTRODUCTION.

**Some imperfections in the original survey of Kashmir.**

SINCE the year 1883, when the first and only general account of the geology of Kashmir appeared (*Mem. Geol. Surv. India*, Vol. XXII), much detailed stratigraphical and palæontological work has been accomplished in other Himalayan areas, notably Kumaun and Spiti, with the result that an extensive belt of very richly fossiliferous sedimentaries in those regions has been fully explored and correlated more or less completely with standard European horizons.[1]

[1] The list of papers and monographs dealing with this subject is too lengthy to quote here, but in particular one may refer to the works of Griesbach, Hayden, von Krafft and Diener, in the Records and Memoirs of the Geological Survey of India, and in the *Palæontologia Indica* (see list of references at the end of this paper).

Until recently no opportunity occurred of testing the old Kashmir sequence by the light of these later surveys, and when such did occur it resulted in a few short and spasmodic visits only. These, nevertheless, were characterised by new and striking discoveries that pointed to some serious deficiencies and not a few mistakes in the original general description referred to above.[1]

If one takes into account the size of Kashmir and the adjacent territories treated of in Lydekker's memoir and map, if one also remembers the rugged, mountainous, and often inhospitable nature of the surface in the more out-of-the-way parts, and finally if one bears in mind the cardinal fact that geology is always progressive, one is not so much struck perhaps by the circumstance that revision has been found necessary over some parts of the area, as by the fact that Lydekker accomplished as much as he did. In such a complex field, those who follow after the original pioneer, fitted out with later knowledge and more complete records of adjacent regions, must of necessity come upon new discoveries and detect certain errors, great or small as the case may be. If, therefore, in this paper I seem to indulge in much detailed criticism traversing Lydekker's early work, I wish it simply to be understood that this arises from the nature of the case, and is in no sense remarkable.

**A new interpretation of the Lidar valley sequence.**

As a case in point, in a recent paper in these *Records* (Vol. XXXVII, pt. 4, pp. 319—327), the result of a few months' visit to Kashmir in 1908, I drew attention by means of, and in consequence of, some sections near Eishmakám, Dowhat (Duwhat) and Lur (Lir) to an interpretation of the structural folds and stratigraphical sequence in the Lidar valley that differed materially from the one adopted by Lydekker (*loc. cit.* pp. 136—138, 227). Instead of there being a number of isoclinal folds of Permo-Carboniferous and Trias rocks (Kuling and Supra-Kuling of Lydekker) repeated among an older system of Panjal traps, slates and quartzites, then believed to be of Silurian and Cambrian age, I provisionally hazarded the opinion that the whole of this seeming complex was merely a regularly ascending series from beds of Lower Carboniferous age exposed at Eishmakám up to the Permo-Carboniferous and Trias of Pailgam (Palgam), taking in on the way in ordinary sequence the so-called Panjal quartzites and

[1] References to the published accounts of these will also be found at the end of this paper.

slates with the supposed Kuling isoclines, the agglomerates, and the Panjal volcanic flows—which last by this interpretation become of about Upper Carboniferous age.

During last summer (1909) I had the pleasure of revisiting the area, and was able to establish fully by further detailed study the provisional conclusions given above. As a result, the stratigraphical sequence at the above localities now becomes as follows in descending order:—

(*f*) Permo-Carboniferous and Trias of Pailgam.
(*e*) Panjal volcanic flows, (? Upper Carboniferous), between Virsiren and Genesbal.
(*d*) Agglomeratic Slate Series, of the neighbourhood of Bhatkot, etc.
(*c*) Fenestella Series (? Middle Carboniferous), Black shales and Quartzites of east bank of Lidar valley, south-south-east of Dowhat and Lur.
(*b*) Passage Beds.
(*a*) Syringothyris Limestone Series, (Lower Carboniferous) of Eishmakám Hill.

This order is also the surface order of outcrop of the beds from Pailgam down to Eishmakám, so that with an apparently steady N. E. dip throughout, there is no need to invoke any complicated folds to explain the present lie of the beds. Confirmation of this was also afforded during last season's work by my tracing to the S. W. of Eishmakám as far as the main opening of the valley S. E. of Shari Bal Station, exactly the same sequence but in reversed order and with opposite dips, a condition which naturally implies the complementary half of one grand anticlinal arch in a normal ascending series of formations.

**Illustrative sections.**

As it is of some importance to appreciate exactly this initial point of divergence between Lydekker's interpretation of the Lidar valley sequence and mine, I reproduce the former's original diagrammatic section from Pailgam to Islamabad as given in his memoir, and with it for comparison I give my own section through nearly the same area (see Pl. 29, figs. 1 and 2). It is necessary to say, however, that some of the differences observable between the two interpretations are due to the line of section being not quite the same. This is, however, only a matter of detail: for the moment the two views thus illustrated may be regarded as a brief statement or opening

of the case. I would specially draw attention to the part of each section marked A—B, which is the *crux* of the whole matter. On the other hand, the inversion or no inversion, as shown at the south-west end of the two sections, is merely a matter of the exact course of that part of the section, which at one place is much as Lydekker has drawn it, and in another as drawn by me.

**Other new discoveries in neighbouring areas.**

From the examination of this question I was gradually led further afield studying neighbouring and related areas, until the accumulated data practically took the form of a resurvey of the portion of Kashmir illustrated in Plate 39. Instead, therefore, of stopping now to enlarge on and give detailed proofs for my particular interpretation of the Lidar sequence (inasmuch as its elaboration is only a single, though important, incident among many new results attained here both as regards structure, stratigraphy, and the defining of several exact fossil horizons), it will be well to re-describe afresh the whole area comprised within the accompanying map. In this way an orderly account of the complete stratigraphical record from Silurian to Trias will be secured, with the above and other long-standing errors and omissions rectified, and much fresh matter of interest introduced.

I have to thank the Kashmir Darbar for permitting me again to work and collect in the State, and for all the facilities accorded me in carrying out my explorations. I must also acknowledge with pleasure the great assistance in collecting rendered me by student Lala Joti Parshad, B.A., who was receiving field-training at my hands. By means of his intelligent co-operation I was able quite to double the amount of palæontological material that I should otherwise have amassed.

## General outline of the stratigraphical sequence.

It will conduce to clearness if for the moment we assume my conclusions, and for descriptive purposes adopt a division of the stratigraphical record embraced in this note into two principal portions, namely, the one below and the one above the great Panjal volcanic series. On that assumption, considering the enormous difference the accumulation of about 10,000 feet of these lavas and agglomerates has made to that sequence, and to the surface results of the mountain area now sculptured out of them, the convenience of such a division becomes obvious. For these volcanic accumulations thereby represent an interval of time, however

great or small it may actually have been, during which events of a revolutionary character moved quickly, and the whole order of things became changed; when peaceful marine sedimentation gave place to volcanic outbursts on so grand a scale that there is but little doubt that great accompanying changes of level and of land and sea areas must have occurred, not only as a consequence of this enormous extravasation of molten magma, but also as a preliminary to it. This is hinted at, as we shall see, by an unconformity below the volcanic series and by the land areas that followed those volcanics bearing a Gondwana flora[1]; whilst the close of this revolutionary period is finally marked by the re-establishment of the Tethys sea and the return again to ordinary marine conditions during Permo-Carboniferous and Trias times.

Furthermore, if the Talchir age, provisionally ascribed to the lower of the Gondwana plant horizons in the Golabgarh pass is correct, the revolutionary nature of the preceding period is accentuated when we recall the fact that widespread glacial conditions then obtained over the continents of India, South Africa, Australia, etc.

The following outline table will now indicate the main sub-divisions in descending order, as determined by my survey :—

## DIVISION B.

*(Above the Panjal Volcanics.)*

11. Upper Trias.
10. Muschelkalk.
9. Lower Trias.
8. Zéwan or Permo-Carboniferous.
7. Gangamopteris Beds (Lower Gondwanas).

PANJAL VOLCANIC FLOWS.

AGGLOMERATIC SLATE.

## DIVISION A.

*(Below the Panjal Volcanics.)*

6. Fenestella Series (? Middle Carboniferous).
5. Passage Beds.
4. Syringothyris Limestone Series (Lower Carboniferous).
3. "Muth" Quartzite.
2. Upper Silurian.
1. Lower Silurian and (?) Cambrian.

[1] *Rec. Geol. Surv. Ind.*, Vol. XXXVII, pt. 4, p. 298.

## DIVISION A.—BELOW THE VOLCANIC SERIES.

### I.—Older Silurian and ? Cambrian.

The lowest horizon which can be maintained with some probability by characteristic fossil evidence is the Upper Silurian, shown on the map as a narrow deep-tinted band bordering all the still older sedimentaries which are here referred to as Older Silurian and ? Cambrian.

**Obscure fossils.**

The exact age of these latter is very speculative. Fossils are not entirely wanting in them, but as far as I have found them they are quite indeterminable, partly because most of them are mere vague outlines or ferruginous smudges and partly because they no longer are aggregated into a well-marked continuous horizon but appear here and there at random—shades or ghosts of fossils that are more numerous and less ill-preserved in the layers near to the Upper Silurian horizon, whilst away at some depth below this their identity as organic remains would not be admitted by anyone who had not followed the process of their gradual effacement step by step from the higher, better preserved, layers. These chance layers of rusty spots and blotches, with occasional shell structure preserved, are all the evidence I can produce that older Silurian and possibly Cambrian are represented. The argument is summed up by saying that they may be traced lying at many hundreds of feet below the Upper Silurian, and as they indubitably are fossil traces, they must be older than Upper Silurian and may be Cambrian. It is not impossible that some future explorer may be successful in finding what I have failed to do, namely, some better-preserved traces of the fauna of these lowermost rocks.

**Distribution.**

The surface area where these older rocks are found is of considerable extent in the portion of Kashmir here described, but there can be no doubt that further S. E. still larger areas are similarly composed. Three main valleys running N. E.—S. W. will be seen from the map to section this main area. They are (1) the Gugaldar-Harpatnar Valley, which joins the Lidar very low down in its course, (2) the valley of the Arpat river descending from Hairbal gali (pass), and (3), the Naubug valley descending from the Margan pass. Beyond the latter another tract of these strata is shown deeply cut through by the Maru Wardwan (river) where the beds become gradually metamorphosed by the intrusion of

the ordinary Himalayan gneissose granite (see sections, Pl. 30, figs. 1 and 2).

**Composition.**

In composition these older Silurian or Cambrian strata are very uniform and characteristic. The predominant feature in them is their thin-bedded, argillaceous and siliceous nature, and their dull pale drab colours, which only here and there become varied shades of purple, blue-grey and pale greenish white. A considerable sandy element, often micaceous, is frequently intermixed with the argillaceous, but sparingly so as never to give a massive or quartzitic aspect to the hill outcrops. There are also some calcareous layers in the upper parts, sometimes white and crystalline, sometimes reddish brown in colour. Near Gugaldar, and between Dardpura and Hairbal (especially in the latter place) as well as at Gauran (Guran) under the Margán pass these limestones attain some thickness. Not a trace of fossils was found in them though they possibly represent the Silurian limestones of Spiti. The mixed, thin-bedded material thus resulting may be generally described as slaty shales, sandy micaceous shales, or fine compacted earthy sandstones, siliceous shales and a few much altered limestones. No good cleavage has influenced them, but an imperfect cleavage is almost universal, whilst in places shearing and cleavage have together brought about a "gnarled" aspect. A phyllitic condition prevails in many places, whilst in the Wardwan valley schistosity becomes more prevalent as a result of the metamorphic action of acid plutonic masses. Like their contemporaries over many parts of the world such rocks might be referred to as greywacke. They give to the country-side soft rounded outlines as a result of the crumbling that inevitably affects soft, but tough, strata of their composition; and they thus have afforded easy progress for the glaciers that in pre-recent times filled these valleys, and whose moraines have still occasionally been preserved. Outcrops of rock can hardly be traced at all on the N. W. slopes of the hills where soil and forest prevail, but the sunny S. E. faces usually afford sufficiently continuous sections.

**Structural Folds.**

The great mass of these greywacke beds, as seen in the main western area, arch over in the form of a great anticlinal fold about a N. E.—S. W. axis, extending from the neighbourhood of Shamahal springs to Gauran in the Naubug valley, and beyond. The angles of dip on the north-east side of the fold under the high watershed and over most of

the area are rather steep, from 40° to 60°, but on the south-west side of the fold in the Arpat river towards Paisan there is slight inversion of the greywackes and succeeding strata, whilst at Gudramer (Gudaman) the same are nearly vertical. The axis of the anticlinal pitches towards the N. W., but the bending round of the strike which follows on this is obscured by the wide stretches of recent gravels of the Lidar valley. At the Margán pass these older palæozoic slates follow under the younger strata forming with them a synclinal trough having steep, practically vertical dips at Lutherwan where the greywackes reappear and continue down into the Wardwan valley. The structural folds in the latter valley could not be followed out. The phyllitic, sheared and incipient augen structures that become so prevalent in the Inshin (Wardwan) representatives of this system indicate much intimate destruction of original structural planes in this valley, as a preliminary to a final schistosity along new lines wherever the gneissose granite bands are approached.

## II.—Upper Silurian.

**U. Silurian fossils identified.**

The identification of relatively well-preserved fossils in the 100 feet or so of strata coming immediately above the system last described, and at several distinct localities, introduces the first new feature in the stratigraphy of Kashmir, inasmuch as Lydekker declared the whole of his Panjal system (which he relegated to the Silurian and Cambrian) to be "totally devoid of organic remains with the possible exception of some obscure impressions from one locality which might be graptolites" (*loc. cit.*, p. 212). Beds of this age, with a characteristic fauna, are now well known to occur in Spiti, Kumaun and Burma, but to the west in Hazara, the Salt Range, and other districts near the North-Western Frontier they have not yet been discovered, though they are known from Afghanistan.

The following is a list of the places where I have collected Upper Silurian remains in Kashmir :—

(1)—Several points between Wajru and Hairbal Gali, including Gugaldar, where many specimens were gathered.

(2)—Just S. W. of Gudramer (Gudaman) in the Naubug valley. This also is a rich locality.

(3)—Below the Margán Pass on the S. W. side.

(4)—At Lutherwan on the north-east side of the Margán Pass. A fairly rich locality.

It is however almost certain that an exhaustive search all round the dotted line as drawn on the map would reveal many more equally good places. The principal localities above enumerated may be shortly described in view of the interest attaching to them.

(1) *Gugaldar*—lat. 33° 51′, long. 75° 25′.—This village lies high up towards the head of the Harpatnar valley at the junction of two side streams. Much of the cultivated area of this hamlet lies on the spit of moraine and gravel-covered easy sloping land between the junction of these two streams. Immediately west of the village on the rocky (west) side of the right side-stream there descends a well-outlined spur from the superposed massive quartzite crags, with more thinly bedded siliceous shales below, and at the very base near the stream bed the 100 feet or so of blue-grey, rusty weathering, sandy shales, occasionally calcareous, and reasonably full of casts and impressions of *Orthis*, etc., coated yellow with limonite—(1) 19-6-09.[1] From this point the strike carries it E. by S. under the fields referred to above, and then along the slopes on the north side of the left side-stream. In the other direction it winds round several spurs on its way across the ridge to near Wajru.

My collection was wholly made from the foot of the spur first mentioned, where a zigzag pathway winds up it. The rock is easy to find, here and at all other localities, if it be borne in mind that it is the topmost of the thin-bedded greywacke coming below the more siliceous shales and finally quartzites of the towering crags above (see section Pl. 30, fig. 1).

A provisional description of the fauna will follow the description of the other localities, as all are practically identical in their fossil content.

(2) *Gudramer* (*Gudaman of Atlas Sheet*)—lat. 33° 41′, long. 75° 27′.—This locality is situated in the high and pleasant valley of Naubug. The beds outcrop nearly vertically from a gap in the ridge to the N. N. W. down to a spur descending to the river-bed at a point $\frac{1}{6}$ mile S. W. and S. of the village. As before, its position can be found by its propinquity to the massive quartzite which follows to the S. W. The rock, though somewhat more calcareous in places, is generally precisely like that at Gugaldar, both petrologically and as regards fossil contents —(1) 11-7-09. It is rudely cleaved (see Pl. 30, fig. 2).

[1] This and similar numbers indicate horizons as shown in the table, sections and sketches.

(3) *Under Margán Pass S. W. side*—lat. 33° 44′, long. 75° 32′.—This is an elevated spot on the talus-covered slopes, after the main ascent to the pass has begun and a well defined steep little moraine has been ascended. It bears N. W. from the Shilsar Pass, where the continuation of the band can be seen to go. The rocky crags (again below the quartzite) are much broken in outcrop, and collecting is difficult. A few specimens however were obtained, both when I ascended and descended the pass—(1) 21-7-09 (see Pl. 30, fig. 2).

(4) *Lutherwan* (*camp*)—lat. 33° 46′, long. 75° 35′.—This locality is among the gently rolling, flower-strewn "margs," before the main descent to Wardwan begins, at some 3 or 4 miles from the actual pass and just at the tree limit. There is no village, the place being only a summer grazing centre for flocks and herds. The fossiliferous band (1) 22-7-09, occurs in scattered small crags, jutting out from the slopes, opposite Lutherwan, and S. W. of the side-stream coming from N. N. W. to join the main stream near the bridge below Lutherwan. The direct path from Wardwan to the pass (not stopping at Lutherwan) goes directly across the beds, keeping to the further (left) bank of the main stream. The crags can be seen to outcrop up the higher slopes to the high ridge to the N. W., where possibly a more perfect section would be got. I did not visit the ridge.

**Petrology.**

The rock is of the usual kind, with a few subordinate brownish yellow calcareous bands. Its position, as regards the lower and upper series with which it is in sequence, is the same as described in the localities before (see Pl. 30, fig. 2).

It may generally be remarked here that a great proportion of the fossil-bearing formations that will presently be described have a very similar composition to that given above. That is to say they consist of a tough sandy shale or shaley sandstone, dark in colour, fine in grain and here and there hardened into lumpy pieces by a small proportion of calcareous matter. The latter (whether residual, and representing what was once a rock of a much more calcareous nature, or not) may here and there become a limestone. In fact the rock seems to change laterally from place to place. During these lateral changes it keeps much the same external appearance. It resists weathering and pressure, and also yields to them, in a minor degree. I am inclined to think that the preservation of occasional fossil layers in them is due to a combination of resistance and yielding to crushing

which a tough rock of this kind can do, followed by differential weathering at and near the surface.

Throughout all these exposures the most common fossil forms represented belong to the family *Orthidæ*. These in fact make up more than 90 per cent. of the whole fauna, and probably include several genera and species. I have not, however, ventured to determine them more definitely; although not a few closely resemble specimens figured by Salter and Blanford (Palæontology of Niti) and by F. R. Cowper Reed from Burma (*Pal. Ind.*, New Series, Vol. 2, No. 3). A few *Strophomenæ* are represented, a small *Spirifer, corals*, among which *Petraia* or *Lindstrœmia* is recognisable, and a fair proportion of small *trilobite* fragments most of which belong to the genera *Calymene*, although *Encrinurus?* and *Acidaspis?* are also represented. One specimen of a *bryozoon* and one large *Orthoceras* complete the list as so far determined.

**Fauna.**

There can be no doubt about the Lower Palæozoic character of this small fauna, whilst the probably Upper Silurian age is rendered stronger by the position of the beds being immediately at the base of what is believed to be the Muth quartzite of Spiti. Without the latter piece of evidence, the correlation of these beds with the Upper Silurian would be somewhat doubtful, as many characteristic forms such as *Heliolites*, *Favosites* and *Halysites catenularia*, Linn., that signalise the Spiti area are as yet unknown from Kashmir. The beds and also those below are generally less calcareous than in the neighbouring Spiti area.

**Age.**

## III.—" Muth " Quartzite.

In apparent normal sequence above the Upper Silurian horizon just described come vast thicknesses of very massive quartzite. The outcrop follows round that of the Upper Silurian, and makes a broad belt between it and the succeeding strata. Having regard to this well-established position and the character of the rock facies itself, it becomes extremely probable that this quartzite is the equivalent of the Muth quartzite of Spiti, etc.

In the main it is a massive quartzite, of granular texture, and of a generally white colour with spots and patches of ferruginous matter, (1) 23-6-09—in all of which characters it repeats exactly those of the

Spiti and Kumaun rock attributed to this horizon. In thickness it must be as much as 3,000 feet in places. Its lowermost beds become thinner-bedded siliceous shales where it passes down into the Upper Silurian.

No fossils have been found in it; so that, as in the case of Spiti and other areas, its exact age cannot be known; the only limits being Upper Silurian below and Lower Carboniferous above. It may therefore be of either of these ages, or it may be Devonian, or represent any two or all three of them.

It is unnecessary to do more than state (as the map shows) that this formation is everywhere found in contact with the Upper Silurian. Even at those localities where the latter has not as yet been established by fossil proof, the Muth quartzite has either been proved to occur, as near Paisan in the Arpat river, or can be recognised from afar as in the cliffs stretching N. W. and S. E. from the Margán Pass.

Unlike the Silurian and (?) Cambrian, it makes very prominent cliffs and precipices at the surface, especially where the dip is only moderately steep. Owing to the pitch of the axis of the anticline, it, like the formations below, disappears in the direction of the Lidar valley by the curving round of the strike, the last remnants of it in this direction being seen at Ainu near Eishmakám and at the N. E. end of the Kotsu ridge, which latter rises isolated out of the gravels of the Lidar river-bed.

## IV.—Syringothyris Limestone Series (Lower Carboniferous).

*Syringothyris* from Kuling.

With this markedly different formation we once more reach a set of beds which at two or three places are rather richly fossiliferous. In the Lidar valley, and probably in the Arpat river, the exposures of these beds coincide partly with areas marked by Lydekker as Kuling and perhaps supra-Kuling, but it is by no means evident that these particular fossiliferous horizons were detected by that observer, or that he collected from them. Certainly the chief fossil, *Syringothyris cuspidata*, does not appear among his collection as described by Diener (*Pal. Ind.* Series XV, Vol. 1, pt. 2, p. 77, 1899) who only mentions two specimens from Kuling in Spiti collected by Stoliczka, and which he (Diener) then observed were preserved in an entirely different rock from the ordinary Kuling shales, and hazarded the opinion that they came from a

lower bed. Later again (*Pal. Ind.* Series XV, Vol. I, pt. 5, p. 147, 1903), it is true, Diener was for the moment misled regarding this genus, which was, however, re-established by Hayden on the strength of more complete material (see *Appendix* to the reference above, added with Diener's approval).

**L. Carboniferous horizon.**

When I wrote my previous paper on Kashmir (*loc. cit.* p. 319), I had only seen these beds at Eishmakám, but believed myself in possession of sufficient evidence to regard them as Lower Carboniferous, and as entering the sequence as noted there and in the Introduction to this paper, that is to say as separated from the Permo-Carboniferous (Kuling) by many thousands of feet of Fenestella shales, agglomeratic slate and Panjal volcanics. Since then the horizon has been traced by me almost continuously over a large area, including 12 miles on the N. E. side of the Silurian anticline from Kotsu in the Lidar valley to Hairbal Gali, whilst on the other side it is in evidence cutting across the ridge between Paisan and Tangamarg (Tanganrag of Atlas Sheet), and is only absent between that point and Kotsu by reason of the covering of alluvium. Beyond the Arpat river in a S. E. direction, as also beyond Hairbal Gali in the same direction, it apparently disappears from the section in company with the succeeding formations by what is regarded as the unconformable overlap of the base of the Panjal volcanics.

At the following localities the series is well exposed and has been collected from by me:—

(1) Kotsu, isolated hill in the plain.

(2) Eishmakám, on two hill spurs descending from Liwapatur Station.

(3) 1 mile N. E. of Ainu (Azim of Atlas Sheet) at the tail end of a spur descending from "Peak No. 1."

(4) Ridge north of pass between Tangamarg and Paisan, whilst the bed was identified (without collecting from) high up the valley above Gugaldar in two separate stream beds, and at the foot of the Hairbal Pass.

**Distinct from the Zewan stage.**

In all these places its position is between that of the underlying "Muth" quartzite and an overlying series, either the slates and quartzites which eventually merge into the Fenestella series (where these are preserved), or the agglomeratic slate and trap, where the latter has overlapped the Fenestella series. In other words its outcrop is separated by many

miles from any typical Zéwan Anthracolithic or Permo-Carboniferous outcrops, and it clearly has nothing whatever in common with them.

(1) *Kotsu, isolated hill in plain.*—Lat. 33° 51½′ long. 75° 18′.—The rock series is mainly calcareous with subordinate shales and sandstones or quartzite, and with a few bands of trap which may be intrusive. A typical section is given in Plate 34 of the Kotsu hill viewed from the N. W., where the main Syringothyris limestone below is 450 feet thick, followed by a trap band, a thin limestone band, and quartzites aggregating 300 feet which are in turn followed by about 100 feet of more limestone. Only the lower 450 feet were collected from, and of this two bands (2) 12-5-09 and (2) 15-5-09 were found to be specially fossiliferous. It is probable, however, that a similar fauna prevails obscurely right through the limestone mass, although the latter was too precipitous to yield more than a hard joint face at right angles to the dip and from which it was impossible to excavate.

This limestone is well-bedded, and of pale and dark grey colours. Where slabby or somewhat weathered, collecting is comparatively easy.

(2) *Eishmakám.*—Lat. 33° 52½′, long. 75° 21′.—In my previous paper (*loc. cit.* Pl. 33), I have drawn a section of the Eishmakám ridge from the locality of Ainu (Azim of map) which only differs in minor points from the above at Kotsu. In it also the fossiliferous layers are in the lower limestones — horizons (3) and (4) 5-9-08.

(3) *1 mile N. E. of Ainu* (*Azim of map*)—Lat. 33° 52½′, long. 75° 22½′.—Beyond the Ainu spur the Syringothyris limestone series can be seen crossing above the village in well exposed beds. After a short interval where they are lost beneath old moraine and boulder banks in the valley, they reappear as already stated at the above locality, which is exactly on the "am" of the word Eishmakám on the Atlas of India Sheet map. This is a long, pointed spur, tailing out west from a group of spurs descending from "Peak No. 1," called "Krapri" locally.

About 150 feet of the limestone as before described can be readily examined. It is sometimes rather pinkish in colour. The upper middle part and upper part are specially fossiliferous, yielding the horizons (2) 14-6-09 and (1) 14-6-09, respectively, and a still lower horizon (3) 14-6-09, (the Syringothyris layer). But the whole section is fossiliferous, full of brachiopods, but so compacted into the rock that they cannot be extracted as a rule.

From this place the series follows the north side of the stream which flows S. W. or W. S. W. from Krapri, (Peak No. 1) and it would appear

that it eventually crosses the main ridge trending S. W. from that peak at a point a little north of a conspicuous gap, to reappear again in the next (Gugaldar) valley.

Besides the limestone proper, there are some sandy limestones as at Ainu, and also some traps of the usual basic kind, the exact relations of which were not seen. There is also a pale rock (4) 14-6-09, much crushed at the edges, forming a narrow vertical dyke only a few feet wide, and cutting across the strike.

(4) *Ridge north of pass between Tangamarg and Paisan in Arpat Valley*—Lat. 33° 46½′, long. 75° 22′.—This is the only locality where the series was found on the S. W. side of the Silurian anticline (for reasons as already explained). The exposure is probably duplicated by folding, but this is not certain. It is of considerable extent laterally, being traceable with breaks from the N. W. side of the gali (pass) overlooking the Lidar valley to near Paisan, a distance of over 4 miles. The dip of the series is reversed, which makes it apparently underlie the Muth quartzite at an angle of 60°, which latter occupies the ridge to the N. E. and has already been referred to as possessing a reversed dip at this place. At the same time it apparently overlies the Panjal traps or agglomeratic slate which here come in contact with it. The general direction of outcrop of the series follows a bridle road joining Tangamarg and Brear. In its N. N. W. extension its strike points directly to the Kotsu exposure.

The complication of stream beds and irregular spurs from the ridge down to the Arpat valley render difficult the deciphering and mapping of the precise irregularities noted above on a small-scale map.

Three good sub-sections are however seen, one a short distance N. E. of the gali where the road crosses the main ridge with fossil horizons (2) and (1) 4-7-09, a second (possibly faulted) low down on the road just before it emerges into the Brear valley, and a third 1 mile S. W. of Paisan with fossil horizon (1) 27-6-09. The last two are manifestly one band. Whatever the detailed explanation of the somewhat disjointed appearance of these two or three outcrops (faulting or folding of some kind), each perfectly repeats in inverted order the same general features and regular sequence in itself and as regards the Muth quartzite and Panjal volcanics (see Pl. 30, fig. 1). The individual sections make this evident, and also make clear the general agreement of the petrological facies of it with the Eishmakám and other sections.

Syringothyris beds overlapped to S. E.

It is of interest to note that whilst south-east of Paisan in the Arpat river, the outcrop of the Syringothyris limestone series disappears for good under extensive alluvial deposits without any reappearance in the next mountain spurs (so far as they have been examined—the N. W. faces of hese spurs are hopelessly forest and soil covered), on the other hand above Gugaldar, and at the base of the Hairbal Pass the approximation of the band in its outcrop to that of the Panjal traps can be seen to be a very gradual process, ending in the final extinction of it before arriving at the Margán Pass. Both at Gugaldar and Hairbal the series is definitely, though not well, seen. Traces of fossils also were found without difficulty, but the locality, lie, and partially obliterating presence of thick forest or covering moraine was adverse to spending time in collecting there.

Fauna.

In spite of the frequently continuous nature, and clearly defined position, of the outcrops of this very characteristic and mainly limestone series, and in spite of the numerous places where collecting was done, the fauna, as regards individual and distinctive species, remains very much where it was after my first season's collecting at Eishmakám alone (*loc. cit.* pp. 321, 233). All the localities have yielded much the same suite of fossils in the same grouping and relative abundance, whilst the negative evidence as to what the beds *do not* contain still stands as the most important criterion — apart from the field relations — for the conclusion that they constitute a single palæontological horizon quite different from either the Fenestella shales which come next above them or the Permo-Carboniferous at a much higher horizon.

The two most characteristic species, namely, *Syringothyris cuspidata,* Mart. and *Chonetes* (?) *hardrensis* var. *Tibetensis,* Salt. must still be relied on as the main connecting link, palæontologically, between this horizon and that of the Spiti (Kanaur) section described by Hayden. Hence if the latter on other evidence (*e.g.*, the presence, along with *Syringothyris cuspidata,* of *Phillipsia* cf. *Cliffordi,* Woodw. and *Helodus crenulatus,* Newberry and Worthen) must be relegated to the Lower Carboniferous, (Hayden, Geol. of Spiti, Mem. G. S. of I., Vol. XXXVI, pt. 1, p. 39, 1904) so these Kashmir Syringothyris beds must also be relegated to the same stratigraphical horizon. Other fossils collected by me, so far as determined, differ but little from those mentioned in my last report. *Productus lineatus,* Waag. is very common; *P.* cf. *scabriculus,*

Mart., *P. Cora* and *P. semi-reticulatus* are fairly common, together with the genera *Derbyia, Athyris* and *Rhynchonella*.

It is possible that a critical examination of this fauna may lead to more definite results. Meanwhile the positive separation of this series of limestones from the Permo-Carboniferous (Kuling of Lydekker), as a unit of provisionally Lower Carboniferous age may be accepted as being in harmony with all the stratigraphical evidence now at our disposal.

## V.—Passage Beds.

Although the higher limits of the Syringothyris limestone series is fairly well marked, there follow above it some considerable thicknesses of unfossiliferous rock before the first bed of the Fenestella series becomes signalised by organic remains. These intermediate rocks consist of quartzites, sandstones and shales over the short area where they can be seen. Petrologically they might be linked with the Fenestella series above rather than with the limestone series below, inasmuch as they resemble the former in all save the lack of fossils, a disability which may even only be local and disappear with further search.

For the present, however, they are placed separately as "Passage beds," and they may be well seen 1½ miles N. N. E. of Eishmakám, where, on the spur from Liwapatur Station descending W. S. W. to the canal bungalow, they occupy all the lower part as far as a line bearing S. E. by E. of Kollur. Above Ainu (Azim) N. E. up the valley opening between Liwapatur and Peak No. 1, the same may be seen up to 2 miles from Ainu, where *Fenestella* first begins.

## VI.—Fenestella Series, ? Middle Carboniferous.

**Erroneously grouped with Lydekker's Kuling.**

From Lydekker's map, descriptions and specimens, the exposures of these rocks in the Lidar valley were certainly included by him with his Kuling. They were examined by me during my first season in Kashmir at one locality only, namely, the little rocky spur on the left bank of the Lidar, S. S. E. of Dowhat and about 3½ miles N. of Eishmakám. But even that brief glimpse of them, considered in conjunction with the series below and above, shook my faith in the isoclinal theory of Lydekker, and showed their distinctness from any of

the ordinary Kuling or Permo-Carboniferous series of Vihi, Pailgam or Golabgarh. The great abundance of *Fenestellæ* and the very rare occurrence of (?) *Protoretepora*, without considering any other faunal elements, made me at once suspicious from a palæontological standpoint, whilst the solid appearance of normal sequence in the series in its position between the Syringothyris limestone and the agglomeratic slate and Panjal volcanics easily fell in with the simple theory of their real intermediate stratigraphical position, when once the Lower Carboniferous age of the Syringothyris limestone was accepted as probable.

**Abundance of *Fenestellæ*.**

Since last year, however, these Fenestella beds have been systematically followed round from point to point in their great loop of outcrop across the Lidar valley and in their many distinct occurrences, always in this intermediate position; so that now, on the strength of their field relations alone, it is impossible to regard them as anything but a set of deposits of older age than the Panjal volcanics, and younger age than the Syringothyris limestone, whilst they are of course out of all direct relation with the *Protoretepora ampla* zone or any other of the Permo-Carboniferous that appear in order only *above* that great thickness of Panjal volcanics.

**True stratigraphical position.**

The localities collected from by Lydekker and described as "north of Eishmakám" or as "8 miles from Pailgam down the valley," as well as his specimens themselves preserved in the Geological Survey type collection, make it fully certain now that we have arrived at last at one of the crucial points where I consider that Lydekker was misled. Returning for the moment to the palæontological argument, it needs but a glance at his specimens gathered from here and figured and named in Diener's monograph on the Anthracolithic Fossils of Kashmir (*Pal. Ind.* Series XV, Vol. 1, pt. 2) to see their total distinctness from the other species also therein described from Khunmu, Barus, Prongam or Pailgam, *i.e.*, from localities now known to be entirely distinct as to horizon. All those characteristic forms such as *Spirifer Rajah*, Salt., *Marginifera Himalayensis*, Dien., *Productus Abichi*, Waag., *Spirifer fasciger*, Keys., *Lyttonia*, *Spiriferina* cf. *Kentuckensis*, Schumard., *Camarophoria Purdoni*, Dav., etc., that appear with due precision at many or all the latter localities, are unknown at the localities marked "north of Eishmakám"; whilst, on the other hand, the abundant occurrence of *Fenestella*, *Spirifer Lydekkeri*, Dien., *S. triangularis*, Mart., *Strophalosia* and *Productus* cf

**Distinctness of faunas.**

*undatus, P. scabriculus*, Mart., together with trilobites (*Phillipsia*) are peculiar to that locality and unknown from all the others.

Probably one of the causes which I conclude led Lydekker astray was a certain similarity between the facies of the rock matrix in which the *Fenestellæ* occur and that of the Permo-Carboniferous of the Vihi, Pailgam and Prongam deposits. But however close this resemblance (and it is not very close after all) it is not closer than that between the Upper Silurian, Permo-Carboniferous and Muschelkalk—as to the distinctness of whose horizons there can be no shadow of a doubt. Even more, however, was Lydekker misled perhaps by the seeming dissimilarity between these shaley bands and the hard solid quartzites with which they are intercalated. This difference in apparent metamorphism is no doubt here and there great, and might easily lead an observer to imagine it not unlikely that the shaley zones were infolded among the quartzites in the isoclinal way supposed by Lydekker; but examination of the intermediate layers between the two at very many places makes it clear that petrological passages occur, and that it is only when the siliceous material had become especially pure and unmixed with argillaceous material that a setting of the sandy matrix into a quartzite took place. In the local descriptions that follow, some examples of these passages will be given; whilst everywhere the interbedded character will be seen to be borne out by the continuity of outcrop right round and over the anticlinal, and the sequence preserved in the same way.

**No evidence of isoclines.**

Above all, nowhere throughout the area is there any structural evidence of isoclines on their own individual merits. An isocline should preserve traces of its synclinal or anticlinal origin by being duplicated in the sequence of its beds from some central line or axis: but nothing of the sort is seen, whilst, on the contrary, each layer of shales between quartzite masses shows a definite petrological change only in one direction coinciding with what must be presumed to be the normal succession of the deposit as laid down in ordinary sequence with the sandy material of the quartzites.

In my previous paper I have already laid stress on the analogous sections in Spiti described by Hayden (Mem. G. S. of I., Vol. XXXVI, pt. 1, 1904) which very completely foreshadow the sequence of these Lidar valley sections as herein detailed; whilst it is plain from the quotations I there gave from that author's memoir that he also (without

having seen the locality) was impressed with doubts as to Lydekker's interpretation of that sequence being correct.

It will be understood from the preceding that I have treated the matter of this normal sequence with some elaborateness, not because I think my mapping and stratigraphical zones are in any way so obscure as to require special pleading to support them, but simply because such circumstantial proofs are in courtesy due to my predecessor, who, from one cause or another, was led to a different conclusion.

**Fenestella series equivalent to Po series of Spiti.**

Accepting then the theory of normal sequence of these beds above the Syringothyris limestone series, we shall be prepared to accept a correlation of them with the Po series of Hayden in Spiti as being in every way reasonable, both on lithological, stratigraphical, and as we shall see later, on palæontological grounds. Their position between the Syringothyris beds and the real Zéwan or Permo-Carboniferous is therefore in entire agreement with that of the Po series, which in Spiti underlies the Permian conglomerate, which is followed in turn by the "calcareous sandstone" of Hayden, and then by the Productus shales (the real equivalent of part of the Zéwan stage in Kashmir).

**Petrology.**

The Fenestella series may generally be described as an enormous thickness (over 2,000 feet) of quartzites, in beds varying from a few feet to 100 feet, and with intervening layers of generally dark shales sometimes slightly calcareous. It is in the lower part that these shales become principally developed and also fossiliferous, carrying their rich bryozoon and brachiopod fauna; whilst towards the middle of the series the shales become less conspicuous and, so far as found, without fossils. Not far from the uppermost limits of the series, however, where they apparently pass into the agglomeratic slate, there recurs another Fenestella-bearing horizon, which is separated from the lower productive shales by an interval of 800—1,000 feet of unproductive rock. Along with the shales, and frequently more in the upper layers, occur ferruginous sandy beds that sometimes pass by gradation into the quartzites above.

**Distribution.**

The area over which this series is exposed is much more restricted than that of any of the previously described formations, whilst it is generally coextensive with the overlying agglomeratic slate. Although the most characteristic sections are found on the banks of the Lidar river and at Lehindajjar, the series with fossils is also well marked in the valley head

between the S. W. spurs of Liwapatur Station and of Peak No. 1 (Krapri), near Buru and at the head of the Kirram Valley, whilst high above Gugaldar and the Syringothyris limestone, quartzites, but without fossiliferous shales (as recognised), appear in diminished thickness under the now approaching base of the volcanic series. Nowhere else to the S. E. in the area have they been recognised, and they thus suffer, in common with the formations below them, the overlapping effect of the Panjal traps, only they (as being higher beds) naturally disappear earlier.

The marked horse-shoe loop made by the bending strike, as the outcrops of the series return upon themselves among the ridges N. W. of Lidar, expresses the same anticlinal with axis pitching N. W., as was remarked in all the lower formations described. A break in the arrangement is however noticed along the Lidar where the outcrops on the N. E. side of the anticlinal are interpreted as being thrown apart by a cross fault along the valley at that point.

The following selected sections may be described here :—

(1) Lehindajjar valley and base of Bhugmore[1] rasta.
(2) Left bank of Lidar valley S. S. E. of Dowhat and Lur.
(3) Head of Kirram valley.
(4) N. N. W. of Buru, near Kotsu.
(5) Valley N. E. of Ainu (Azim) between S. W. spurs of Liwapatur and Krapri.

(1) *Lehindajjar valley and Bhugmore rasta*—Lat. 33° 55', long. 75° 18'.—Lehindajjar is a somewhat scattered upland village lying about 2 miles N. W. of and above Wallarhama, on the direct bridle road connecting the Lidar valley with the Traal valley by the pass known as the Bhugmore rasta. It also partly occupies the opening of a tributary valley of some size descending due south from the lofty peak, Churu (11,332 feet).[2] The bed of the Lehindajjar valley and portions of the connecting side valleys, lie flatly among the lower more shaley members of the Fenestella series, the latter by their disintegration producing a wide area of gently sloping culturable fields. Above these towards all points of the compass, but especially to the N. and N. E. of the village

[1] In the edition of the Atlas sheet, with corrections to 1904, on which the geology has been represented (Pl. 39) the word "Bhugmore" has been deleted. Bhugmore rasta is the pass over the ridge N. W. of Lehindajjar.

[2] The height of this and other trigonometrically fixed points is a few feet less than the values given on the old atlas sheets.

rise somewhat picturesque hill-spurs and slopes separated by water-courses, which, as they gradually emerge from their overburden of alluvium and gravels, yield some of the best sections in the Fenestella series. On the way up the valley from north of Wallarhama to the foot of the pass, these spurs, by the alternation of quartzite and shale, show very prominently the bending round of the strike from W. N. W.—E. S. E. to W.—E. and finally to W. S. W.—E. N. E. with corresponding dips to N. N. E., N., and N. N. W. of 40°.

The table that follows and the section (Pl. 31, fig. 1) show the smaller divisions or stages of the series, the table being in descending order :—

AGGLOMERATIC SLATE (ABOVE).

8. Uppermost Fenestella shales, containing also a branching bryozoon. Thickness small but unknown.
7. Quartzites and slates. No fossils. 500—600 feet thick.
6. Black, sandy shales with very few *Fenestellæ.* 100 feet thick.
5. Quartzite. 60 feet thick.
   (Passage beds).
4. Shaley sandstones, dark grey and mottled greenish grey and black below. Traces of fossils. 200 feet thick.
   (Passage beds.)
3. Dark shales full of *Fenestellæ*, corals, brachiopods and lamellibranchs.—(Camp horizon). 150 feet thick.
2. Quartzite. 60—100 feet thick.
1. Sandy shales or shaley sandstones, full of fossils as above. Many *Productidæ.*—(Lehindajjar Bed). 500 feet thick, (base not seen).

The shales and sandy shales of beds Nos. 1, 3, 4, 6 and 8—which sometimes might also be called imperfect slates—are penetrated by a rude cleavage. They frequently also contain pyrites pseudomorphs, even among the fossils. The internal evidence of the section just given, with its varied petrological sequence, obviously does much to dispose of the isoclinal theory ; and even more so does the solid deeper structure of spur and ravine as laid bare by denudation. What with the latter and the deep cross-cut through the series made by the gorge from Churu we can follow the beds to the dip for many thousands of feet without any sign of wavering—any appearance of recurrent, reflexed folds which are necessary on Lydekker's theory. If, however, we were to assume that the reflexed isoclinal folds demanded by that theory might be of so great amplitude and so closely packed that even in this greatly

sculptured area they could appear as parallel beds, this would only make more impossible the bending round of the strike in loop fashion, a phenomenon which nevertheless is known actually to take place.

Fauna.

Of the fossiliferous more shaley layers in the Lehindajjar section just given, Bed No. 1, the lowermost and more sandy division of the shales containing horizons (2) and (3) 24-5-09, is best exposed at Lehindajjar itself on both sides of the gorge descending from Churu Station. The fossils which are ferruginous casts embrace: *Fenestella* sp., corals, *Spirifer* cf. *grandicostata*, McCoy, *S. Lydekkeri*, Dien., *Productus* (?) *scabriculus*, Mart., *P. semireticulatus*, a few more indeterminate brachiopods and *Modiola*. Bed No. 3 (camp horizon), (2) 23-5-09, occurs higher up the valley at a point half-way between Lehindajjar and the foot of the Bhugmore rasta. It and the quartzites below are well exposed in the little ravine to the east of the bridle-road. A good collection, but poor in variety, was made here, embracing *Fenestella* sp. in predominating quantity and rather well preserved, a few corals, *Spirifer* cf. *grandicostata*, McCoy, *Modiola* and *Pecten*. In bed No. 4, (1) 26-5-09, which follows directly above No. 3, was found *Productus* cf. *scabriculus*, Mart. The rest of the shaley horizons above No. 4 yielded only a few *Fenestellæ* and some ill-preserved and much crushed brachiopods, together with a branching bryozoon in bed No. 8. The latter (the uppermost Fenestella bed,) (3) 27-5-09, was found *in situ* on the Bhugmore rasta, and identified by fragments high up in the Churu ravine.

(2) *Left bank of Lidar valley S. S. E. of Dowhat and Lur*—Lat. 33° .55′, long. 75° 21′.—The section here, which has its centre at the little cliff descending to the bridle road near the bridge and which was described in my previous paper, is almost equally convincing in its regular sequence through much the same set of beds, but the outcrop of the lower shales and sandy shales is partially obscured by a tangle of scrub jungle (see Pl. 31, fig. 2). The latter also appear much thicker, *i.e.*, continue further south than I had noticed when I wrote that paper. The full section by stages is as follows :—

AGGLOMERATIC SLATE (ABOVE).

6. Uppermost Fenestella shales with branching bryozoon, (1) 1-6-09. Small thickness. At a point about 2 miles S. W. of Bhatkot.

5. Quartzites and shales. Large but uncertain thickness: the section could not be measured owing to recession of hill-spurs from the river-bed.
4. Ferruginous sandstone, (2) 13-9-08, (last year's number) (see section, Pl. 31, fig. 2). Twenty feet thick. Probably the equivalent of the top of "camp horizon" in the Lehindajjar section. This and the remaining numbered stages are all in continuous cliff section.
3. Great thickness of black Fenestella shales occasionally calcareous, sandy shales, with occasional more sandy beds and a little quartzite, and containing horizons (3) 13-9-08, (5) 13-9-08, (4) 13-9-08, (1) 6-9-08 (last year's numbers) and (1) 6-6-09, as shown in the section pl. 31, fig. 2. Thickness over 1,000 feet. Probable equivalent in part of Lehindajjar bed.
2. Trap (intrusive).
1. Quartzite and more Fenestella shales for an uncertain thickness until the passage beds (p. 222) are entered on the hill-spur above the canal bungalow at a point S. E. by E. of Kollur.

Of the above section it is practically certain that beds 3 and 4 represent those referred to by Lydekker as being "north of Eishmakám" and "8 miles from Pailgam down the valley" and from which his collection described by Diener was derived. A collection also made by F. Noetling in 1902 from 2 miles north of Eishmakám would seem to have been derived chiefly from these horizons. The specimens, registered Nos. K. 6. 514—586, remain unnamed and undescribed in the geological survey collection.

*Fenestellæ* and a few examples of (?) *Protoretepora* occur abundantly throughout the more shaley layers. In the lowest horizon collected from, (1) 6-6-09, there are also a coral, one small fragment of a trilobite, *Productus* cf. *undatus*, Defrance; *P.* cf. *scabriculus*, Mart.; *Spirifer grandicostata*, McCoy; *Spirifer Lydekkeri*, Dien.; *Rhynchonella* and other fragments.

An almost identical fauna appears in (1) 6-9-08, (last year's number) found in large loose blocks, by the river side near the Fakir's hut, and which may have been derived from near the same bed. During my previous visit I accorded it a position too close to (4) 13-9-08 and assumed

it, probably erroneously, to be approximately *in situ.* The rock is calcareous in parts.

The horizon (4) 13-9-08 (last year's number) is prominent as appearing in cliff section actually at the Fakir's hut and cave overlooking the road. A large number of *Phillipsia* fragments characterise this bed, together with *Modiola* and most of the species in fragmentary state as given above. From the prominent aspect of the bed, the contained fauna, and the nature of the rock matrix, this was clearly one of the main sources of the specimens gathered by Lydekker. It is calcareous in patches.

Horizon (2) 13-9-08 (last year's number) which is more sandy than any of the others, presents the forms *Dielasma* (large species) *Spirifer* cf. *triangularis*, Mart., a few other undetermined species of *Spirifer, Productus semireticulatus*, Mart., *P. scabriculus,* Mart., a large *Camarophoria* and *Eumetria* cf. *vera,* Hall.

The continuous cliff section by the bank of the river ends with this bed, as shown in the figured section (Pl. 31, fig. 2). Stages 5 and 6 of the table given at p. 228 are only seen in discontinuous exposures in the side-streams and side-spurs as they recede from the main river bank beyond the bridge. The map is too vague in topographical details to further define these outcrops, but the overlying agglomeratic slate sets in some little distance before the important side-stream opposite Lur is reached.

From the above sketch of the fauna as provisionally determined by me, we may now rest certain that these beds as a whole are the ones collected from by Lydekker 8 miles from Pailgam down the valley and described by Diener (*Pal. Ind.* Series XV, Vol. I, pt. 2.). Their agreement also petrologically, and as to their prevailing fossils (the great abundance of *Fenestella, Productus undatus* and *P. scabriculus*), with the Po series of Kanaur, Spiti, described by Hayden (Mem. G. S. of I., Vol. XXXVI, pt. 1, pp. 49-50) seems also to be beyond dispute, especially since they appear in exactly similar sequence as regards the formations below and above, only excepting the trap beds of the volcanic series which seem to be absent in Spiti, at least as regards sub-aërial flows. Much of the grits along with the Permian conglomerate of Hayden, which are described as lying above the Fenestella series, must, undoubtedly, correspond to my agglomeratic slate. The description of the former as being "composed of angular and rounded fragments of shale and limestone embedded in a coarse slaty matrix" (*loc. cit.* p. 51)

agrees perfectly with much of what I have classified together under the comprehensive title of agglomeratic slate.

It only remains to point out that Hayden's correlation of his Po series with the Zéwan beds of Kashmir must now, in the light of my later work, be understood to be only a correlation with the Fenestella beds of the Lidar valley, which, having been wrongly grouped by Lydekker with those Zéwan beds, came to have their fauna described by Diener along with the fauna of the latter.

**Fault in Lidar valley.**

A structural feature of some interest in connection with the sections just described is the cross-fault down the Lidar valley. If the strike of the Fenestella shales S. E. of Dowhat which is N. W. by W. with a dip to N. E. by N. of 30°, is considered, it will be seen that the outcrop of the same, if uninterrupted, should cross the valley and reappear on the other side between Kollur and Dowhat; whereas such is not the case, and all that stretch of country is occupied by the agglomeratic slate. To explain this hiatus a fault is assumed along the bed of the river at this place. This fault, however, would appear to have died out higher up the valley where the Panjal traps make their appearance in the section, inasmuch as the outcrops of the latter meet at the river, having suffered no displacement at all.

(3) *Valley N. E. of Ainu* (*Azim*).—Away from the actual bed of the Lidar river to the S. E. the Fenestella series can be followed across the spur which descends W. S. W. from Liwapatur Station to the canal bungalow (1½ miles N. N. E. of Eishmakám), and from there across the intervening spurs to the valley N. E. of Ainu. Here at 2 miles N. E. of that place the series extends for some considerable distance up the valley. There are no good continuous sections, but enough is seen to completely identify them (see camera sketch Pl. 33.)

The high spurs between here and the Gugaldar valley were not actually crossed by me, and as already mentioned the section high above Gugaldar is much covered, and only the quartzites of the series were exposed in their much thinner outcrop here. It is practically certain, however, that all these spurs would yield abundant traces of typical fossils if sections free of soil, forest, moraine or talus could be found.

(4) *Head of Kirram Valley*—Lat. 33° 54′, long. 75° 15′.—From Lehindajjar and the east slopes of the Bhugmore rasta the boundary

between the Fenestella series and the agglomeratic slates, though not followed for the next mile or so, has been limited within very narrow confines by work on both sides of the main ridge. Beyond that it is again found fairly sharply defined at the head of the Kirram valley at a point 3 miles N. N. E. of Kirram, where the series is characteristically developed with plenty of fossils, (1) 8-8-09, though there is no good section. With a steep S. W. dip, and strike N. W.—S. E., the same continue and were next found by me near Buru in the valley of the Lidar again.

(5) *Buru* — Lat. 33° 51′, long. 75° 18′.—Here at Buru it will be perceived that we have arrived at the S. W. side of the grand anticlinal, and the identification of representatives of the Fenestella series at this point was not a difficult task when once their position was presumed from, and limited by, the Syringothyris limestone of Kotsu and the agglomeratic slate above. There are some hundreds of feet of the shale probably not all fossiliferous, good fossils being found in a bed 50 feet thick at a point at the foot of the hills due E. by N. of Shari bal station and N. W. by N. of Buru village, (1) 13-5-09. They continue up the slope and are found also on the ridge of the near spur. They dip 60° S. W., and pass beneath and possibly up into the agglomeratic slate.

## PANJAL VOLCANIC FLOWS AND AGGLOMERATIC SLATE.

This great series of rocks which I have used as a convenient dividing series between divisions A and B of the fossiliferous formations, is characterised by very definite basic lavas in its upper part, and by what I have called agglomeratic slate in its lower part. The two constitute Lydekker's Panjal trap and Panjal conglomerate, respectively, and are frequently found together over large parts of Kashmir, being well developed in the Pir Panjal, or Panjal range, from which the series takes its name.

**Origin of the agglomeratic slate.**

Whilst the upper traps are eminently characteristic volcanic flows, the lower agglomeratic slate presents some difficulties. That it is a clastic rock of some kind seems to admit of no doubt. Much of it from its dark grey colour and the nature of its matrix might be described as a fine grit or greywacke, composed chiefly of angular grains of quartz set in a still finer vague matrix which was probably once of the nature of clay, rock

flour or ash, or it may partly be cataclastic mylonite. But dotted about at random through this matrix occur larger fragments, sometimes rounded, but more generally sharply angular (like the smaller grains of quartz) and composed of quartz, felspar, slate and quartz-porphyry, with occasional quartzite, pegmatite and even tourmaline-granite fragments. These range in size from bits as large as a pea to others the size of the fist. When they become very large the rock becomes generally much more quartzose and the larger pieces are then more rounded. The finer-grained rock is the predominant rock and is easily recognised wherever occurring by the angular fragments or by the cavities whence such fragments have been weathered out on exposed surfaces. It is generally imperfectly cleaved, in common with all the fine-grained rocks of this region.

But having acquiesced in its clastic origin, it is not so easy to define the exact nature of the agency by which it was accumulated. It is certainly not a simple stratified deposit laid down under the action of water. Although the sharply angular nature of the smaller quartz grains forming the matrix might not have been altogether adverse to this conclusion, the angular state of the larger fragments demands some other explanation. There seem to be two main natural agents by which such a wide-spread and uniform deposit might have been accumulated, namely; (1) explosive volcanic action, and (2) frost with ice transport.

If we accept the former as being congruent with the lavas which followed, we have to admit the entire absence of glassy or pumiceous material in the rock matrix as now seen, although subsequent devitrification or silicification with crushing and development of mylonite, sericite, calcite and other secondary minerals might account for the condition of the rock as we now see it.

**Possible Talchir age.**

On the other hand, if we accept the alternative explanation for the origin of such a rock which in many respects resembles the Blaini conglomerate (the glacial origin of which seems now beyond dispute—see Rec. Geol. Surv. of India, Vol. XXXVII, pt. 1), we must nevertheless admit that no striated, grooved or facetted boulders have so far been found in it. In this connection it is of interest to note that the first fossiliferous horizon found above the agglomeratic slate and undoubted volcanic traps, namely, the *Gangamopteris* and *Psygmophyllum* bearing beds of the Golabgarh pass (Rec. Geol. Surv. of India, Vol. XXXVII, pt. 4, p. 293) are very probably of Talchir age or at least of Lower Gondwana age, and

that therefore the agglomeratic slate might after all synchronise fairly well with the wide-spread glacial boulder deposits of that age in South India, the Salt Range, and other austral regions.

Although unable to discuss the subject here (I shall hope to do so in another paper) I incline to the explosive volcanic theory, and so include the agglomeratic slate as the lower member of the volcanic series. That is to say I regard it as an accumulation of clastic and sedimentary material formed round ruptured portions of the earth's crust which eventually became foci for the extrusion of basic lava flows. At the same time the alternative hypothesis should not be lost sight of, nor the possibility that the formation was a joint product of both sets of activities combined with ordinary sub-aërial sedimentation.

**No fossils.**

One factor in the question which should not be overlooked is that the agglomeratic slate, even in its finest-grained varieties, contains no organic remains throughout the whole thickness of the formation. Although it is probable that the Fenestella shales in their uppermost layers pass up into the agglomeratic slate without any break in the continuity of deposition, every trace of fossils ends when the material begins to be agglomeratic. Unfortunately, however, the absence of organisms might be understood under either supposition as to the mode of formation of the rock, so that we are left as before very much in the dark on this point. Only one conclusion seems to emerge as satisfactorily demonstrated, namely, that the rock is no ordinary slate or greywacke deposited under normal marine conditions such as obtained when the Silurian or Fenestella shales were laid down.

**Distribution.**

As shown by the map, the agglomeratic slate interbanded with a few quartzites occupies what is generally a wide outcrop of horse-shoe shape following round the outer margin of the Fenestella shales and dipping with them at about 40° on the N. E. side of the anticlinal and at about 60° on the S. W. side. The limit of the outcrop at the N. E. extremity of the horse-shoe as far as can be ascertained is coincident with the limit of the Fenestella shales, but on the S. W. side the outcrop, with much diminished thickness, continues almost as far as the trap itself. The agglomeratic slate is everywhere of a very crumbling nature and rapidly disintegrates under weathering and is slightly calcareous in places. It is unnecessary to describe any special sections in this rock series. At Buru in the southern part of the Lidar valley ; and again further north

between Kollur and Virsiren, as well as further west on the east slopes of the Traal valley and the ridges and slopes about Churu Station, enormous thicknesses are laid bare, dipping steeply towards regularly varying points of the compass under the Panjal traps as the strike changes in conformity with that of the succeeding beds both below and above.

After what has already been said regarding the underlying Fenestella shales, the Syringothyris limestone, Muth quartzite and Upper Silurian slates, it is enough merely to remark in passing that this formation is entirely unrelated to the much older Silurian and (?) Cambrian greywackes in the Harpatnar, Arpat, Naubug and Maru Wardwan valleys.

The question as to whether one would be justified in similarly separating all the occurrences of Panjal conglomerate mentioned by Lydekker in his memoir from the presumably much older slate series bearing the same name is not of course easy to decide. From my own knowledge I can only be certain of one other area, namely, that of the Pir Panjal range in the neighbourhood of the Golabgarh pass. There, although I did not detect any fossiliferous rocks coming below the anticline of agglomeratic slate, I found the latter at every point underlying volcanic traps which in turn underlie Lower Gondwanas, followed by the Zéwan or Permo-Carboniferous.

**Panjal volcanic flows.**

With regard to the traps themselves, only a brief reference here will be attempted. They are distinctly bedded and very massive (see Pl. 28 showing the crags above Gugaldar). Amygdaloidal and compact bands are both very common. Many specimens of these rocks were submitted by Mr. Lydekker to General McMahon, whose descriptions are quoted by that author (Mem. XXII, p. 218, *et seq.*). My own collection and rock slides corroborate their identification of them as genuine old basic lava flows. Their greatest thickness like that of the agglomeratic slate must amount to many thousands of feet. None are porphyritic, all the specimens that I have collected being altered microcrystalline aggregates of basic felspars and finely granular augite with iron ores, and here and there traces of glassy base. No olivine is present.

**Overlap.**

The outcrops extend with or without the agglomeratic slate, as already stated, far to the S. E. of the immediately underlying Fenestella and Syringothyris beds so that there is successive overlap or unconformity between

them and those underlying formations, until in the Naubug valley and on the Margán pass they repose directly on the Muth quartzite with only a thin conglomerate between. In all these places, as also in the Golabgarh pass, they build fine walls and precipices of rock and fill the ravines at their feet with enormous blocks and boulders detached from them. The map and sections will further illustrate the general extension of these beds both S. E. of the Lidar valley and also N. W. to join up with the Wastarwan and Zebanwan masses. Although unconformity or overlap is indicated above all the lower formations, their present general lie with steep dips of from 40° to 30° on the N. E. side of the anticline is generally conformable with that of the subjacent groups, at least there is no marked discordance between them. The same is true in their steeper lie on the S. W. side of the anticline and their vertical or even inverted position near Naubug and Paisan (see general sections across the anticline.)

In addition to the bedded traps, other parts of the area, as for instance the Lidar valley near Kollar, show dykes of what most likely was the same magma, cutting through the agglomeratic slate on one side of the valley and through the Fenestella shales on the other. Similar dykes or laccolitic masses are found between Mandra and Batton in the Traal valley. Of these undoubtedly igneous lavas and dykes as well as of the underlying agglomeratic slate I hope to give a description in a separate paper.

## DIVISION B—ABOVE THE VOLCANIC SERIES.

## VII.—Gangamopteris Beds (Lower Gondwanas).

**Golabgarh Pass.**

In my previous paper on Kashmir I have described the occurrence of a thick series of siliceous and carbonaceous shales and of hard grey sandstones and carbonaceous shales, the latter containing characteristic Lower Gondwana plants, as lying directly above the volcanic traps in the Golabgarh pass. In the area treated of in this paper these beds are reduced to the very thin layer of Gangamopteris-bearing shales of the Risin spur and neighbourhood which have already been fully described by previous observers (for references see my previous paper).

**Near Pansapura.**

The only fresh locality within this area brought to light during last season's explorations is the extremities of two spurs, 3 miles E. by S. of Pansapura

(lat. 33° 51′, long. 75° 11′) at the S. S. W. foot of the Kamlawan mass of trap rocks (5,601 feet), which mass is the counterpart of the Wastarwan mass on the opposite side of the opening of the Traal valley. Here, although only a doubtful Gangamopteris was found, there is a thickness of 200—300 feet of carbonaceous and siliceous shales and a few limestones, coming directly above the massive trap, and which there is a strong probability are the equivalents of the Gangamopteris beds of Risin spur. The shales weather white, just as at Risin and Zéwan. They are frequently silicified, as also are some of the limestone beds. Specimen (1) 9-8-09 is a sample of these shales with plant impressions and *? Gangamopteris.*

The sequence in these spurs differs from that of all the others in the neighbouring areas by the plant-bearing shales being overlaid by more trap and fine ash, 200—400 feet thick, and which appear to take the place of the lower part of the Zéwan beds inasmuch as they in turn are followed by a massive grey bryozoon limestone with *Camarophoria.* As the section is then obscured by alluvium and surface accumulations it is impossible to be certain on this point.

## VIII.—Zéwan or Permo-Carboniferous.

**Some new localities and zones.**

With reference to the succeeding Zéwan or Permo-Carboniferous beds, it is unnecessary in this note to do more than draw attention to one or two new localities whence characteristic fossils have been obtained, and to add a few particulars to one or two of the sections in the Vihi area described in my last paper, which otherwise fully illustrates the sequence of these strata.

It will be seen that the new, more comprehensive, map with this paper continues the outcrop of the Mandakpal horizons beyond that village in an E. and N. N. E. direction across the Patarkul R. *viâ* Pastannah (Pastooni of the Atlas sheet), Lám and Narastán. These localities all lie along the line of outcrop as correctly marked by Lydekker on his original map.

I will first of all refer to the old localities of the Guryul Ravine and Mandakpal, where one or two new horizons must be inserted and a slight modification of my last year's section is required.

(1) *Guryul Ravine.*—If the reader will refer to plates 29 and 30 of my last paper (Rec. Geol. Surv. of India, pt. 4, 1909) he will find a set of dark, sandy, micaceous shales indicated on the spur above the Chenar

trees at the entrance to the gorge. These follow above the *Protoretepora ampla* horizon, and in 1908 yielded no definite fossils for the first 400 feet above that bed. Last year (1909) I was fortunate enough to find a new horizon at a point about 100 feet above the *Protoretepora* bed. It is calcareous and lenticular, about 1 foot thick, occurring among the sandy shales on the arête exactly on a level with the summit of the Chenar trees, (1) 10-10-09. It contains well-preserved specimens of *Productus semi-reticulatus*, Mart., and *P.* cf. *Gangeticus*, Dien., in large numbers. Another smaller bed 50 feet above this, (2) 10-10-09, contains *Athyris* sp.

(2) *Mandakpal.*—If the reader will also refer to plate 32 of my previous paper (upper figure) he will find three points of outcrop marked (2) 14-8-08, which (p. 311 of that paper) were rather doubtfully referred to one continuous horizon. The same bed also seemed doubtfully duplicated in the section 2 miles north of Barus (p. 315). I have now ascertained that in the former section there are really two separate horizons embraced under the number (2) 14-8-08. The lower of these is the one marked as "best fossil locality," whilst the others at the two points marked with the same number are really somewhat higher in the scale and are characterised by containing *Spirifer Rajah*, Salt. in predominance, almost to the exclusion of everything else. The matter was definitely settled by my finding the latter *in situ* directly on the slope above the "best fossil locality" and by my tracing the "best fossil locality" exposure almost continuously along the slope to the distant ridge slope shown in plate 32, where it should be inserted as cutting the spur between the points there marked (2) 14-8-08 and (1) (2) 16-8-08, respectively. The upper bed I have now indicated by the number (1) 2-10-09, and it may be easily distinguished from (2) 14-8-08 by the fact that it contains no *Marginifera Himalayensis* and no *Productus Cora.*

Two other less important horizons were found above and below (1) 2-10-09 respectively, so that the sequence of horizons in the Permo-Carboniferous of Mandakpal now becomes as follows in descending order as far as the *Protoretepora ampla* limestone:—

(0) 2-10-09, containing corals and *Chonetes* in matted groups.

(Ten feet of unproductive sandy shales.)

(1) 2-10-09 [previously included with (2) 14-8-08] containing *Spirifer Rajah* in predominance, a somewhat broader form perhaps than in (2) 14-8-08. Other species found were *Spirifer fasciger*, Keys., *Chonetes*, and a *Productus* of the *fimbriati* group.

(Ten feet of unproductive shales.)

(2) 2-10-09, containing *Athyris,* corals and *Productus* of the *fimbriati* group.

(Fifty feet of unproductive sandy shales.)

(2) 14-8-08, (equivalent of "best fossil locality" of plate 32), containing in the uppermost hard dark limestone *Spirifer Rajah, Marginifera Himalayensis* and *Productus Cora* in large numbers with rarer *Dielasma LaTouchei, Athyris, Camarophoria* cf. *Purdoni, Spirifer Nitiensis,* Dien. *S.* sp., *Spiriferina Kentuckensis,* Shumard., *Productus Abichi* or *gangeticus,* Dien., corals (*Amplexus ?*) and *Aviculopecten.*

In the lowermost layer of shales below the limestone there are chiefly *Marginifera, Spirifer Rajah* (a small variety), corals, *Lyttonia* and *Aviculopecten.*

(Eighty feet of unproductive shales.)

(1) (2) 16-8-08 and *Protoretepora ampla* horizon.

I collected very largely from horizon (2) 14-8-08, and my specimens now number some hundreds of each of the three chief forms, some of which are very well preserved, and include many specimens of *Spirifer Rajah,* complete with both valves; whilst all the other species are well represented by many examples. This bed at Mandakpal, indeed, may be regarded as one of the richest and best preserved of any of the life zones in this part of Kashmir. The genus *Camarophoria* is represented by a form intermediate in size between *Purdoni,* Dav. and *gigantea,* Dien.; some other forms of *Camarophoria* in this bed, however, differ very widely from these two typical shapes and will probably constitute new species.

I was also able to add considerably to my collection from horizon (1) 16-8-08 of last year.

(3) *Pastannah* (*Pastuni of Atlas Sheet*—lat. 34° 0′, long. 75° 8′ ). To reach this locality from Mandakpal one must cross over the pass to the east which carries the bridle-road connecting Mandakpal with the Patarkul[1] and Traal valleys. The village lies on alluvium and talus fans, which descend from the neighbourhood of the pass to join the river gravels in the Patarkul valley. Away to the south-west the massive beds of the Wastarwan Panjal traps can be seen descending in great sheets with dip slopes to the north at fairly steep angles. But attached to the upper beds of these and near the base of the slopes there are secondary little spurs given off, introducing Permo-Carboniferous

[1] Written "Patark" on the new atlas sheets.

rocks and (as we shall see later) Trias. Owing to the thick forest covering these slopes there are no good sections. To the S. W. of the village, however, and 200 feet above it the upper *Spirifer Rajah* bed (1) 11-9-09, was found with *Productus* cf. *gangeticus*, Dien. etc., among sandy shales of the usual kind. Below it there were 50—100 feet of more sandy shales and then grey limestone with no fossils for 100 feet. The section is then interrupted by a stream-bed, behind which come the first sheets of the Panjal traps. At this locality, therefore, it will be seen, there are no traces of the Protoretepora limestone. In the other direction above the *Spirifer Rajah* zone the series continues in the ordinary way for some distance, and then becomes gradually more calcareous as we approach the Lower Trias (see p. 242).

(4) *Lám*—lat. 34° 2′, long. 75° 10′, *and Narastán*—lat. 34° 4′, long. 75° 10′.—From Pastannah to near Lám surface deposits cover the junction of the trap with the B division of the fossiliferous series. At Lám itself, also, the Permo-Carboniferous rocks are not seen on account of a side stream descending directly along the line of outcrop of these beds. At Narastán, however, in the next little side valley to the north there are a few traces of dark micaceous sandy shales, about 150 feet thick, (1) 23-8-09, from which *Productus semireticulatus* and a few other brachiopods were obtained. Here, however, as at Lám the actual junction of the overlying beds with the Panjal traps could not be detected on account of the side ravines and forest. The evidence, so far as it goes, points to the Permo-Carboniferous being represented here; but the failure to find the characteristic *Protoretepora ampla* zone either here or at Pastannah makes me suspect that there may be a dying out of this formation in this direction. Still further to the east in the isolated outcrops of Permo-Carboniferous and Trias at Pailgam, as was noticed during my first season in Kashmir, the Permo-Carboniferous formation was very imperfectly developed.

The strike at Lám and Narastán varies from N. N. E.—S. S. W. to N.—S. with steep dips to W. N. W. and W. respectively.

## IX.—Trias.

**New fossil horizons.**

The preceding year, 1908, it will be remembered that a *Meekoceras* horizon of the Lower Trias was discovered by me in the sections E. of the Guryul ravine near Khunmu in the Vihi district, together with a probable

representative of the Muschelkalk above it. I was particularly fortunate again last year, 1909, in my examination of the Trias formation along the newly explored line of outcrop between Mandakpal and Narastán, and in my re-examination of the Khrew and Khunmu areas visited the season before. The neighbourhood of Pastannah was especially prolific in good sections with abundant horizons of characteristic cephalopods, many of which are well preserved. They include an *Ophiceras* horizon in the Lower Trias and a very full sequence in the Upper Muschelkalk comparable to many of the Central Himalayan sections in Garhwal and Kumaun. What are presumed to be representatives of the Upper Trias have, however, so far yielded no cephalopod fauna, though there are many brachiopods and lamellibranchs. The *Otoceras* horizon at the base of the Lower Trias is also still wanting in this area.

The following statement in tabular form gives a summary of the Trias horizons so far detected in this part of Kashmir:

| | | |
|---|---|---|
| UPPER TRIAS. (Many thousands of feet thick). | Unfossiliferous massive limestones. | |
| | *Spiriferina Stracheyi* and *S. Haueri* zones. | |
| | Lamellibranch beds. | |
| MUSCHELKALK. (About 900 feet). | *Ptychites* horizon: | sandy shales with calcareous layers. |
| | *Ceratites* beds: | Do. |
| | *Rhynchonella trinodosi* beds: | Do. |
| | *Gymnites* and *Ceratites* beds: | Do. |
| | Lower nodular limestone and shales. | |
| | Interbedded thin limestones, shales and sandy limestones. | |
| LOWER TRIAS. (Over 300 feet). | *Hungarites* shales (position uncertain). | |
| | *Meekoceras* limestones and shales. | |
| | *Ophiceras* limestones. | |

### (*a*) LOWER TRIAS.

1. *Pastannah* (*Pastuni of Atlas sheets:* lat. $33°$, $59\frac{1}{2}'$, long. $75°$ $8'$).—Whilst working out the excellent sections in the Muschelkalk at this place, I was unduly detained by a spell of rainy weather, and my attention was then drawn to numerous blocks of clear, dark, blue-grey limestone among the gravel and detritus fans near the village, and which

were seen to contain a very well preserved *Ophiceras* fauna. It was some time before I was able to track these to their home *in situ,* where they occupy (as shown in the camera sketch, Pl. 35) the secondary little spurs (mostly forest-covered) W. by S. of Pastannah village, referred to p. 240. The outcrops are very imperfectly shown because of the prevailing forest and soil-covered dip slopes, but their position as overlying the Zéwan (Permo-Carboniferous) and underlying the Muschelkalk, admitted of no doubt. They consisted of blocks *in situ,* and occasional definite layers of dark grey, compact limestone, protruding from the soil-cap of the occasionally-found barer slopes.

The apparent dip follows that of the beds below and above and is approximately 40° N. N. W. Owing to the down-hill dip, it is not easy to estimate the thickness, but there must be at least 300 feet, of which some 50 feet are specially fossiliferous, [(1) 5-9-09].

**Ophiceras bed.**

The commonest form of ammonite in these lowermost Trias limestones is present in great abundance, single blocks often yielding a large number of specimens compacted together. Occasionally individuals may be broken out from the rock in a very fair state of completeness and preservation. A large percentage seem to belong to Diener's amplification of Griesbach's genus *Ophiceras* (*Pal. Ind.*, Series XV, Vol. II, Pt. 1, p. 100) although in no single instance is there visible any of the delicate concentric or spiral striation that is supposed to characterise the innermost layer of the shell. Other differences are to be found in the transverse section which is never cordate, only occasionally lanceolate, and generally roughly oval with no well-marked umbilical margin or wall.

Nevertheless, the general similarity of the forms in size, shape, ornamentation, sutures and range of variation to those united by Diener into his group *Ophiceras Sakuntala* cannot be denied, and with this group therefore I am compelled provisionally to classify them.

*Ophiceras,* according to Diener, is entirely restricted to the lowest division of the Trias, the *Otoceras* beds. As already remarked, the latter genus is apparently wanting in this part of the Kashmir area, so that it is quite possible that the forms discovered by me may be slightly different in horizon and exact affinities.

The two species of this group to which most of my specimens most nearly correspond are those of *O. Sakuntala*, Dien., and *O. ptychodes,* Dien., but the two seem to pass into each other by transitional forms,

whilst there are others, *Ophiceras* sp., with characteristics which seem to connect *Ophiceras* and *Xenodiscus* (*Danubites*).

An almost equally large percentage of ammonites in this bed belong undoubtedly to the genus *Xenodiscus* (*Danubites*). Several species seem indicated, but I have not attempted to sort them out specifically. All or most have a general similarity to the species described by Diener and von Krafft (*Pal. Ind.*, Series XV, Vol. II, pt. 1, and Vol. VI, pt. 1). There are also a few other undetermined fragments of ammonites.

*Orthoceras* and *Pseudomonotis* are represented by a fair number of specimens.

*Hungarites.*

All the above have been gathered both *in situ* on the hill outcrops and from loose blocks in the detrital fans, but a few other forms, a ? *Proarcestes* (one small specimen) and about 40 well-preserved small specimens of *Hungarites*, one *Xenodiscus* and some *Meekoceratidæ* were only found in the detrital material. They occur in a shaley matrix, which I much regret having been unable to locate *in situ*. As the nature of the matrix is so different from the normal Lower Trias it cannot be presumed that these specimens of *Hungarites*, etc., really came from the Lower Trias, and they may have been derived from some other higher horizon. This unknown horizon has been indicated by (X) 4-9-09.

On returning to Calcutta Mr. Hayden drew my attention to a quantity of fossils already in the Survey collection from this locality, Pastannah (Pastooni), gathered by F. Noetling (K. 6. 58, K. 6. 108 in the Fossil Register) and identical with those of horizon (1) 5-9-09. No details concerning them are to hand, the Register simply giving the name of the village without any further comment. It is probable that Noetling obtained them, as I did at first, from loose blocks, as there was no sign of any previous excavating at the *in situ* places whence I collected.

(2) *Lám*—(lat. *34° 2′*, long. *75° 10′*).—Between Pastannah and Lám the recent gravel banks and fans of the Patarkul R. hide outcrops of the Lower Trias. At Lám itself, on a small spur immediately north of the village, some rather doubtful dark grey limestones, of which 300 feet are exposed, very probably represent the upper part of the Lower Trias. Some obscure traces of *Pseudomonotis* and of ammonites were found in horizon (3) 20-8-09, near the top of these limestones and just below a marked cattle track winding up the spur from the village and also in horizon (4) 20-8-09 about 50 feet above (3) 20-8-09 (see camera sketch, Pl. 38). No trace of the *Ophiceras* horizon of Pastannah, however, was

found there, and there is good reason for supposing that its position is still lower in the section and buried out of sight by the detrital accumulations somewhere in the neighbourhood of Lám village itself.

(3) *Narastán*—(lat. 34° 4′, long. 75° 10′).—At this village, however, there seems to be a perfectly continuous section from the presumed Permo-Carboniferous sandy shales with *Productus semireticulatus*, etc., (1) 23-8-09, into a set of thin-bedded, dark grey limestones, which, some hundreds of feet above (1) 23-8-09 and immediately above Narastán village, contain numerous ill-preserved traces of ammonites, (2) 23-8-09. The specimens are much and deeply weathered, but there is good reason for thinking that they are the real representatives here of part of the Lower Trias, the rock being very similar to that at Pastannah. But, from the fact that no typical *Ophiceras* layer was found in this very clear section, one is tempted to conclude that it is really absent, having died out just as seems to have been the case with other still older horizons (*e.g.*, the *Protoretepora ampla* zone). Deficient observation may, however, still be shown to be the true cause of this apparent absence, inasmuch as the Lám and Narastán sections were visited before the Pastannah Lower Trias horizons had been discovered.

### (*b*) MUSCHELKALK AND UPPER TRIAS.

Whilst the Lower Trias, when present, is only found poorly exposed on obscure dip-slopes, as for instance to the south of the valley leading down from the pass to Pastannah; the representatives of the Muschelkalk and Upper Trias are well exposed, and occupy the base or lower part of a long line of scarps that rise with increasing steepness as higher and more massive beds of the Upper Trias appear, and which finally build an array of picturesque crags and precipices towering high above the surrounding country. As these sections are everywhere continuous upwards from the Muschelkalk into the Upper Trias, and as the uppermost limits of the former are not precisely known, it will be well to take the two together in the present description of them.

(1) *Pastannah—Pastuni of Atlas sheet:* lat. 33° 59½′, long. 75° 8′.—Immediately to the north of the detrital fan on which the village is situated rises a conical shaped hill-spur which is seen to be connected by a little neck, forming a marked gap, with the higher continuation of the same spur leading up to the culminating wall of crags. A *camera lucida* sketch of the spur is shown in Plate 36 and a section of it and the succeeding horizons above in Plate 32.

The base of this conical hill begins with 200 feet of dark grey, rather thin-bedded limestone, containing no fossils with the exception of a few occasional lamellibranchs. The dip of it and the succeeding strata is 30°-40° N. N. W. Whether this bed belongs to the Lower Trias or to the Muschelkalk is uncertain, but petrologically it more nearly resembles the former. This changes somewhat abruptly into 200 feet of interbedded thin limestones and shales, of a buff colour, amongst which also no fossils have so far been detected.

We then pass into grey-coloured, thin-bedded, rough-weathering, sandy limestones, with a lamellibranch horizon, (0) 27-8-09, near the base. After 100 feet of this we pass into pale-coloured, more nodular, sandy limestones, with hard shaley partings standing out on weathered edges, the whole having suffered much from crushing. This continues for nearly 200 feet with a few obscure traces of cephalopods, especially in bed (1) 3-9-09 which is 80 feet below the well-marked horizon of (1) 27-8-09 which will be used for reference as a datum line, and a number of black lumps which represent cephalopods, at a position 15 to 20 feet below the same horizon. Between the two the nodular grey limestone continues as before until about 5 feet below (1) 27-8-09 when a gradual change sets in and the rock becomes of dark red and neutral colours, and of an earthy, lumpy, calcareous and sandy nature, very tough under the hammer and containing a rich fauna. During this 5 feet we pass through cephalopod horizons (2) 3-9-09 and (3) 3-9-09, and finally arrive at (1) 27-8-09, a rather slabby, hard representative of the dark-red, earthy limestone, a foot or so thick, and especially full of *Gymnites*. It stands out prominently on the outline of the hill. This is followed by 20 feet of black shales and then by horizon (2) 27-8-09 which very nearly repeats the characteristics of bed (1) 27-8-09, but it is not quite so red in colour. We are now near the top of the outlying hill-spur, the rest of the way to the rounded summit being through strata which gradually become more shaley again, and of a drab colour. These continue to the little gap before-mentioned, a thickness of about 400 feet, within which are some fossil horizons, as indicated by a few specimens picked up on the slopes and which are marked (1) and (2) 30-8-09, but have not been otherwise located. Horizon (1) 12-9-09, found on an adjacent spur, is about 50—100 feet above; (2) 27-8-09 must come somewhere about these horizons.

We have now probably passed out of the Muschelkalk and have arrived among the lamellibranch horizons of the Upper Trias marked

(3)—(7) 30-8-09. They all occur in a set of alternating grey or drab limestones and shales, the calcareous layers increasing as we ascend until the rock finally becomes altogether a massive limestone in which nothing but obscure traces of lamellibranchs can occasionally be detected.

In the above section the petrological characters of the rock elements down from the *Gymnites* layers, (1) and (2) 27-8-09, to the base of the nodular limestone, have a great resemblance to the Kumaun and Garhwal sections, a resemblance which is also carried out in their fossil content. But upwards from that datum line the lamellibranch beds (3)—(7) 30-8-09 present us with thick stratigraphical units which are quite unlike those of the Kumaun and Spiti sections, there being no Upper Trias ammonites represented, and also none of the very characteristic Daonella shales or Halobia limestones.

The fossil contents of the various horizons in the above section from below upwards, as provisionally determined are as follows :—

From horizon (0) 27-8-09, *Pseudomonotis* sp. A thin bed full of them.

From (1) 3-9-09 and another bed 20 feet below (1) 27-8-09 some indeterminate fragments of ammonites.

From (2) 3-9-09 the genera *Ceratites, Sturia ?, Acrochordiceras, Orthoceras, Meekoceras* in large numbers, and a few lamellibranchs.

From (3) 3-9-09 *Ceratites* sp., *Acrochordiceras, Gymnites* sp., *Meekoceras* sp. in large numbers, *Ceratites* (*nodosi* group), *Orthoceras, Nautilus* and a large lamellibranch. It should be noted that the last two horizons are not sharply distinguished from (1) 27-8-09 above, and for practical purposes may be considered as one bed with it, 5 feet thick, of which (1) 27-8-09 constitutes the uppermost layer.

From (1) 27-8-09, which is by far the most richly fossiliferous, many examples of *Ceratites Thuillieri*, Opp., one or two of *C. Himalayanus*, Blan., *Hollandites* cf. *Voiti* or *Ravana*, Dien., *Ceratites* cf. *Airavata*, Dien., *Ceratites* sp., a few examples of the genera *Proarcestes* and *Acrochordiceras*, one *Danubites*, one small *Ptychites*, many *Meekoceras*, a large number of undetermined fragments of ammonites, several fine examples of *Gymnites Jollyanus*, Opp., and many of *Buddhaites Rama*, Dien., also *Gymnites* cf. *Sankara*, Dien., and a large number of undetermined species of *Gymnites*, many *Orthoceras* and *Nautilus*, a few undetermined lamellibranchs, *Athyris* sp. and a few gastropods.

From (2) 27-8-09, many *Hollandites* sp., *Ceratites* sp., one fragment of *Gymnites, Acrochordiceras* and *Orthoceras*.

(Above this point in the section no more cephalopods appear actually *in situ,* though one or two specimens were picked up some hundreds of feet above (2) 27-8-09. It thus appears that the well-marked *Ptychites* horizon of other sections presently to be described is either absent here or has eluded observation.)

From horizons (1) and (2) 30-8-09, not found actually *in situ,* and at a level of some 200 feet above (1) 27-8-09, were obtained some fragments of coarsely ribbed *Ceratites* and some gastropods; whilst from (1) 12-9-09 at about this horizon or a little lower on a spur further to the west, a large number of *Rhynchonella* sp. and some ammonite fragments.

Near the marked gap on the ridge (continuing the original section), but rather down the slopes towards the east, from horizon (3) 30-8-09, which is about 400 feet above (1) 27-8-09, a large number of sometimes beautifully preserved specimens of a small *Avicula ?* or *Pecten.*

From (4) 30-8-09, which is 30 feet above (3)—, larger forms of somewhat similar lamellibranchs, *Avicula* or *Pseudomonotis,* together with many *Myophoria* and a few other undetermined lamellibranchs.

Similar forms are found in bed (5) 30-8-09, twenty feet above (4) —, and in beds (6) and (7)—, about 200 feet above (3) and (4)—. In bed (6) also occur a few brachiopods, *Athyris* sp.

From this provisional list of fossils it may now be accepted as proved that a fairly rich and typical upper Muschelkalk, and with probably some Upper Trias fauna, is present in Kashmir in addition to the Lower Trias already proved. The identification and tracing of these well characterised horizons adds considerably to the geological record in this part of the Himalaya and brings Kashmir into line with Spiti, Garhwal and Kumaun. Here, however, as in the other sections presently to be described, there is no trace of a Lower Muschelkalk fauna, as particularly exemplified by the genus *Monophyllites,* the characteristic group of *Ceratites subrobusti* (*Keyserlingites,* Mojs.) and the brachiopod layers with *Rhynchonella Griesbachi,* etc.

But it should be noted that these discoveries were not altogether unanticipated, inasmuch as scattered fragmentary fossil evidence had already shown the practical certainty that a Muschelkalk fauna existed. For instance Lydekker in his general work, page 146, mentions briefly that Stoliczka obtained *Ptychites Geradi,* Blan., close to the village of Thajwaz [Sind valley?] and says:—"these rocks may therefore be referred to some part of the Trias . . . In Hundes the beds in

which the above-mentioned fossil occurs are referred by Mr. C. L. Griesbach (Rec. Geol. Surv. of India, Vol. XIII, p. 103) to the upper part of the Lower Trias (Muschelkalk)." Also Diener (*Pal. Ind.*, Series XV, Vol. 2, p. 98) mentions that among the collection from Kashmir in the Geological Survey Museum, Calcutta, sent to Vienna for description "there is only one fairly preserved specimen of *Ceratites Thuillieri* from Sunamarg which points to the presence of Muschelkalk." Again Diener (*Pal. Ind.*, Series XV, Vol. V, Mem. 2, p. 138) writes:—"In a letter written shortly before his death A. v. Krafft has drawn my attention to the fact that the Muschelkalk fauna known from Kashmir is not confined to *Ceratites Thuillieri*, Oppel., as stated by me (*loc. cit.* p. 98)." v. Krafft then adds *Gymnites Salteri*, Beyr., from Ladakh (exact locality unknown), and *Proarcestes Balfouri*, Opp., and *Ptychites nov. sp. ind. ex aff. malletiano*, Stol., from localities which there was internal evidence from the labels to show were probably to be found in Kashmir.

(2) *One mile W. of Pastannah.*—For some distance to the west of the section just described in the Muschelkalk and Upper Trias, the lower and more interesting part of the sequence of horizons remains covered by detrital accumulations. On the actual pass leading over to Mandakpal the sections are also obscured by the prevailing forest and deeply soil-covered grassy slopes. But between the two, at a point about one mile W. of Pastannah, a few partial sections may be found on the bridle-road ascending to the pass, and others in the stream-bed in the vicinity. From one of the latter a further collection was made from the *Gymnites* layer, (1) 8-9-09, which is the equivalent of (1) 27-8-09. The section is a steep little undercliff in the bed of the ravine, which may be recognised from Pastannah by the bare rock showing among the vegetation. In the *camera lucida* sketch, Plate 35, it is represented behind and to the right of the Lower Trias horizon, (1) 5-9-09. Here, as in the previous section, the *Gymnites* band forms a prominent steeply dipping ledge of harder rock, whilst both it and the nodular limestone below may be traced to the east slanting across the slopes to cut the bridle-road and making a series of little falls in the water-courses which join the main ravine from the north. These may easily be recognised as they compose a series of graceful precipices dropping down into the forest-covered gorge at their foot.

Owing to slight step-faulting along the face of the crag it was

impossible to make a correct detailed section, and collecting was *only* attempted from the uppermost *Gymnites* layer.

The following species were obtained from bed (1) 8-9-09 = (1) 27-8-09, some well preserved examples of *Gymnites Jollyanus*, and *G.* cf. *Jollyanus*, also of *Buddhaites Rama* and *Ceratites Thuillieri*, fragments of *Ceratites* (coarsely ribbed species), one example each of a small species of *Ptychites* and *Proarcestes*, and fragments of *Orthoceras* and *Nautilus* with a few lamillibranchs and gastropods. One very large *Gymnites*, but broken and in a poor state of preservation, had a diameter of 12½ inches, which is somewhat smaller than the specimen mentioned by Diener from Rimkin Paiar (*Pal. Ind.*, Series XV, Vol. 2, part 2, p. 51).

(3) *Khrew, in the Vihi plain*—(lat. 34° 1′, long. 75° 4′.)—Continuing along the outcrop of the Muschelkalk and Upper Trias over the covered sections on the pass and those on the Mandakpal side of the pass, nothing further was found worthy of detailed exploration until Khrew was reached. The appearance of Muschelkalk at this place proved somewhat of a surprise. During my previous visit to these sections I only just touched the rocks of the Temple hill on my way from Weean to Mandakpal, and did not appreciate the fact that a sharp fold at this place repeated lower beds than the Upper Trias of the Weean spur. Such, however, in 1909 was found to be the case, and a very fine and clear section of the same was brought to light. Thus, in spite of the outcrops of the Permo-Carboniferous trending away from Mandakpal towards W. S. W. and then S. to the spur 2 miles N. of Barus (see plan, Rec. Geol. Surv. of India, Vol. XXXVII, pl. 31), a small irregularity of folding (quite simple but impossible to describe without detailed plans) makes a tiny outcrop of the Muschelkalk reappear in the hills N. W of Khrew where previously only Upper Trias had been surmised to be present. In general structure and configuration the spur containing this Muschelkalk formation bears a strong likeness to the spur north of Pastannah, both in the way the particular beds occur and the relative position of the gaps on the ridge-crest.

The lowermost beds in this section are exposed on the W. S. W. face of the temple hill, quite close to Khrew town. They appear in the core of a normal anticlinal fold, and consist of lower barren limestones, about 150 feet thick, followed by about 100 feet of limestone and calcareous sandy shale which sheet the lower end of the spur on which the temple stands (see sketch, Pl. 37). Then follow about 80 feet of pale nodular limestone, the equivalent of the nodular limestone at Pastannah

hill. These in turn merge into about 20 feet of reddish calcareous shaley sandstone, (2) 17-9-09, which exactly reproduces the similar reddish rock of the *Gymnites* layer, (1) 27-8-09, in the Pastannah hill section, and like it is separated by some dark shales from an upper *Gymnites* bed, (1) 17-9-09, which outcrops on the very summit of the temple hill, and is the equivalent of (2) 27-8-09. This well-recognisable horizon will again be used here as a datum line from which to reckon the position of any of the succeeding beds and fossil horizons. Its paler lower beds have abundant traces of fossils present as black lumps in the matrix, but nothing good can be extracted except here and there.

From (1) and (2) 17-9-09 was collected a fauna very similar to that of the Pastannah *Gymnites* bed, but much less good, including *Gymnites* sp., *Ceratites Thuillieri,* and other *Ceratites, Proarcestes, Meekoceras, Nautilus,* etc. (This and the succeeding rock stages and fossil horizons are well illustrated in camera sketch, Pl. 37, which is also sufficiently detailed to serve as a section through the series here.)

Above these two horizons from the summit of the temple hill the rock becomes more shaley again, but with calcareous and sandy layers down into the first gap on the ridge and across it to the summit of the prominent little hill (bearing N. 15° W. from Khrew and represented in the camera sketch) a thickness of 350 feet up to beds (4) and (3) 15-9-09. The strata here at the surface are dipping about 40° E. N. E. and they consist of dark crumbling sandy and micaceous shales, with harder bands of tough shaley limestone, the whole being roughly but persistently cleaved.

Bed (4) 15-9-09 consists of these crumbling shales and is full of small brachiopods, chiefly *Rhynchonella* cf. *trinodosi*, Bittn., of which some hundreds were easily collected on the bare weathered surfaces and dip-slopes. *Spiriferina* cf. *Griesbachi* or *Haueri* is also present. From (3) 15-9-09, a more hardened layer outcropping at the little summit, were extracted *Ceratites Thuillieri, Gymnites* sp. and three other undetermined ammonites.

Half way between the little summit and the next gap to the north at (2½) 15-9-09 which is 125 feet above (3)—, a single example of *Ceratites Thuillieri* was found in similar crumbling shales. At 125 feet higher the little gap is crossed, similar beds continuing, and we then ascend for 35 feet more in the section (which is now beginning to be more calcareous) to bed (2) 16-9-09 which is remarkable for large numbers of lamellibranchs chiefly *Pseudomonotis* sp. with *Myophoria* and some other

undetermined genera, together with several examples of *Buddhaites Rama*, *Gymnites* sp., *Orthoceras*, *Nautilus*, one small *Ptychites* and one large one (*? Megalodisci* group) and one *Ceratites Thuillieri* (?). The presence of the genus *Ptychites* introduces us to a new cephalopod zone, which, however, is much better developed in the Khunmu section (see p. 252).

Generally in this bed as in much of the crumbling shales altered by cleavage, fossils are poorly preserved and difficult to find and extract. Dim traces of what were such are seen occasionally on breaking the rock but a good specimen is only found where differential weathering has operated. Even then the ammonites are extremely rare, having only a scattered distribution and demanding arduous search with pick and crowbar.

Above the last horizon, which corresponds to somewhere near horizon (3) 30-8-09 of the Pastannah section, cephalopods entirely cease, the rock becomes gradually more calcareous and we are presumably in the Upper Trias.

About 150 feet above (2) 16-9-09 comes bed (3) 16-9-09, a thin zone amongst the prevailing massive limestone and containing a few examples of *Spiriferina* cf. *Haueri*, Suess., one *Rhynchonella* sp. and another brachiopod.

Beyond this again, following the spurs round to the north of Khrew, nothing but massive limestone with a few shaley layers occur. They build majestic cliffs, the scarped faces of which are absolutely bare and show the dip planes inclined at 30°—40° E. N. E. At ¼—½ mile beyond the spur N. W. of Khrew a few bands occur of ochre-weathering limestone (1) 15-9-09 containing a small *Spiriferina* cf. *Stracheyi*; dip N.E. by E. at 42°. A similar bed (2) 15-9-09 a few hundred yards further on contains an identical fauna. All these beds remind one of those above the *Spiriferina* cf. *Haueri* horizon of the Monastery Hill near Arapal and Lám in the Patarkul valley.

Beyond this point to Bathan, a horizontal distance of about 2 miles the same, generally clear, blue-grey, compact limestone continues in one unbroken outcrop dipping at about 40° with the exception of some quartzites about the position of the "S" of the word Sathpukrin on the Atlas of India sheet. Once more beyond this due east to Zantrag at the next valley head, the same rocks continue, but beyond this they become bent into a series of synclinal troughs, generally more or less reversed or with more steepening dips to the S.W. than to the N. E. up to and including

the high peak at the junction of the ridges S. by E. of Tamnag Station where we seem to be somewhere near the central axis of the syncline as a whole and in the highest beds of this mighty limestone formation. Throughout all this enormous thickness the rock appears to be absolutely barren of organic remains.

Returning for a moment to the Khrew spur section, we find the strike bending round rapidly but steadily to the west, W. S. W. and S. W., until at the S. E. foot of the Weean spur the lowermost beds of the Upper Trias with *Spiriferina* cf. *Stracheyi*, (1) 14-8-08 (last year's number), make their appearance dipping to the N. W. Thus the detrital material and alluvium of the valley between the Khrew spur and the Weean spur hide all continuation of the Muschelkalk in this direction.

(4) *Spur 2 miles N. of Barus.*—In addition to the Upper Trias of the isolated hill at the end of this spur and the dip slope of presumably Lower Trias described in my last paper (*loc. cit:* pp. 314—316) I may now add that on again visiting it in 1909 I came upon reddish calcareous earthy sandstones, feebly exposed in the hollow between the spur and the isolated hill which exactly reproduce the rock of horizons (1) 27-8-09 and (2) 17-9-09, namely, the *Gymnites* bed of the Pastannah and Khrew sections. Although no fossils were found in these chance outcrops, I consider the correlation of the bed with the Muschelkalk justified on petrological grounds.

(5) *Khunmu.*—In addition to the account given in my previous paper (*loc. cit.* pp. 304—306) of the Muschelkalk spur N. N. E. of Khunmu, I have to add here the finding during my second visit of a very characteristic *Ptychites* fauna at and about the horizon given as "near (7) 11-8-08." Several large weathered specimens were first found in the stream-bed to the east of the spur (B) 6-8-08 (see Plate 29 of my previous paper) and, by a careful series of cross traverses up the dip slope of the spur to the point marked "near (7) 11-8-08," many more were picked up, including some actually *in situ* in the beds associated with the lamellibranch fauna of that bed. It is evident that these very large forms are exceedingly scarce in this horizon, and I do not think they would have been discovered at all but for the good luck of having an extensive dip-slope to search over after denudation had played its part. Occasionally one of these great discs would be found *in situ*, but completely weathered out, and just ready to be launched down the slope by the next heavy rain. The following were collected here:—*Ptychites* (*megalodisci* group, one of which appears identical with *P. Sumitra*, Dien.),

nine specimens, the largest of which has a greatest diameter of 215 mm., *Ptychites* sp. (small forms) 6 specimens, as well as specimens of *Pinacoceras, Gymnites, Proarcestes, Ceratites Thuillieri,* and *Nautilus.*

The exact horizon of the above fauna is probably not far from that of the bed (7) 11-8-08, collected from last year. But it is undoubtedly higher than (6) 11-8-08, the brachiopod bed with *Rhynchonella trinodosi,* etc., and which I correlate with the similar bed in the Khrew section.

The particularly rich, red coloured *Gymnites* bed of the Pastannah and Khrew sections is therefore evidently not exposed in these Khunmu outcrops, but must lie buried out of sight in the detrital fans. A search for the same up the ravine to the west between the Muschelkalk spur and the Lower Trias dip slopes was quite unsuccessful.

(5) *Lám neighbourhood*—(for lat. and long. see *ante*).—Returning back along the outcrop of the Trias into the Patarkul valley at Arapal and Lám, we find the structure there to be as represented in the profile view, Plate 38. Almost the same view, but seen in the distance in combination with the Pastannah section, is also roughly outlined in Plate 36 whereby it is made plain that the two exposures are mutually continuous with each other, though partly hidden beneath the covering of Recent deposits in the Patarkul valley. These Lám exposures are, however, not quite so good as those at Pastannah, and the harvest of fossils obtained was proportionately less. The general strike is N. E.—S. W. with dip to the N. W. into the hill.

The lowest beds in the Lám section seen on the spur immediately above the village, and numbered (3) and (4) 28-8-09, have already been mentioned as probably the uppermost portion of the Lower Trias (see p. 243). The beds which follow above these it will be seen from the drawing have been searched by me as they successively appear on the nearer spurs in the direction of the Ziarat (monastery). These various spurs were taken for examination in preference to following the one spur to the summit of the hill because of their accessibility (being more or less along the line of the water channel which supplies the needs of the monastery) and because of the clearer and more diverse exposures which they afforded. Their relative order with regard to each other is sufficiently represented in the sketch (Pl. 38).

Coming above the (?) Lower Trias there is first about 300 feet of the usual dark grey, sandy, shales, slightly micaceous, with roughly lenticular bedding and imperfect E.—W. cleavage. which must represent all the lower part of the Muschelkalk section of Pastannah, Khrew, etc.,

but no fossils were found until horizon (3) 16-8-09 was struck. This and the three succeeding horizons, fairly near to each other up to (4) 16-8-09, are all fossiliferous, containing the usual Upper Muschelkalk forms, including *Ptychites*. They are generally somewhat calcareous layers in the usual shales. The species obtained with their horizons are as follows :

From (3) 16-8-09, which is 300 feet above the (?) Lower Trias, a specimen of *Buddhaites Rama*, fragments of *Gymnites* sp., several other fragments of undetermined ammonites, and a large number of *Pseudomonotis*, identical as to species and habit in the rock with those from bed (2) 16-9-09 in the Khrew section.

From ($3\frac{1}{2}$) 16-8-09 one specimen of *Ptychites* cf. *rugifer*, Opp., and a fragment of a large ammonite.

From ($3\frac{3}{4}$) 16-8-09 *Ceratites* sp., *Orthoceras* and *Pseudomonotis*.

From ($3\frac{5}{6}$) 16-8-09 *Ceratites* cf. *Thuillieri*, *Ptychites* cf. *Geradi*, some undetermined fragments of ammonites, and *Nautilus*.

From (4) 16-8-09 *Ptychites* sp., *Pseudomonotis* and other obscure lamellibranchs, *Rhynchonella mutabilis*, Stol., *Rh.* sp. and other undetermined brachiopods.

It is clear from the abundance of *Pseudomonotis* and the *Ptychites* that the set of beds, (3)—(4) 16-8-09 might represent the horizons (2) 16-9-09 of the Khrew section and "near (7) 11-8-08" of the Khunmu section, that is the uppermost portion of the Upper Muschelkalk. Like them too, the fossils, especially the cephalopods, are difficult to detect, only appearing here and there in a scattered distribution in their horizons, and generally remaining hidden in a husk or shell of half-weathered rock, from which they can only be extracted with considerable expenditure of energy. But inasmuch as (4) 16-8-09 has also a strong likeness to (1) 12-9-09 and to (3) (4) 15-9-09, it is unsafe to do more than bracket the whole from (3) 16-8-09 to (6) 16-8-09 with the whole of the Pastannah section from (2) 3-9-09 to (5) 30-8-09.

Above this the Upper Trias must be presumed to begin. The examples of *Ptychites* and other cephalopods cease, and the various lamellibranch and brachiopod horizons, especially those with *Spiriferina* cf. *Haueri*, evidently correspond to the similar horizons in the other Upper Trias sections. The rock also gradually becomes much more calcareous and the shaley bands get less and less.

From horizons (5) 16-8-09, which is 200 feet above (4)—, many

lamellibranchs, including *Myophoria* sp., which remind one of the horizon (4) 30-8-09 at Pastannah, and several other forms of undetermined lamellibranchs.

This is followed by other, less good, lamellibranch horizons, which increase in numbers and generally show matted-together remains. For instance from :—

(6) 16-8-09, which is 325 feet above (5) — , and which forms a prominent rocky knob on the ridge, a small *Avicula* (?) in a hard blue-grey limestone.

Then come a few sandy shales and hard thin bands of grit or quartzite, a few feet thick, with limestone bands.

From (1) 20-8-09, a little above (6) 16-8-09 more lamellibranchs in hard pale grey limestone.

From (1) 16-8-09, at about 300 feet above the last, *Spiriferina* cf. *Stracheyi*, Salt., and undetermined lamellibranchs occur in a rich little bed of dark grey and ochre-coloured limestone with a few interstratified shales. There are probably more than one of these beds not far from each other, and they manifestly represent the beds with the same prominent species in the Khrew section.

Above this the limestones gradually become more massive and blue grey, getting clearer above, and with chrome coloured blotches, until about 400 feet above (1) 16-8-09, with *Spiriferina* cf. *Stracheyi* the uniform slope ceases, and the rock stands up, very massive, in an almost vertical wall as prominently seen in the sketch (Pl. 38). These and all the overlying very great thicknesses of limestone are apparently barren of all organic remains.

(6) *Narastán* (for lat. and long. see *ante*.)—Beyond Lám, to the north, the Trias outcrop was only followed by me as far as the Narastán side-valley, which joins with the Patarkul valley higher up the course of the latter. A slight general bending of the strike carries the outcrop of Trias and Permo-Carboniferous almost due north from Lám across the intervening ridge. Exposures with fossils are poor. Whilst doubtful representatives of the Lower Trias occur as already described at Narastán, somewhere just below that village the Muschelkalk must be hidden by the boulder-strewn bed of a feeder of the Narastán side-valley which comes down from the north.

In the Upper Trias which is well displayed in the rocky spurs to the west of this point the first bed of limestone seen yielded horizon (1) 25-8-09 with *Spiriferina* cf. *Haueri*. A little further west

still, and about one mile from Narastán in the bay of the hills, (2) 25-8-09, with a solitary example of a *Nautilus*, whilst still a little further on comes (3) 25-8-09 with more *Spiriferina* cf. *Haueri* and near it the crinoid limestones (4) and (5) 25-8-09.

In the annexed table are shown at a glance all the fossil horizons, from Silurian to Upper Trias, which have so far been discovered by me during the two seasons spent in Kashmir. They are arranged in order of age. By following the columns down vertically in any locality compartment, one passes successively through older and older beds. On the other hand, all the zone numbers found in one horizontal line are supposed to be of the same age. In case of doubt about any particular fossil zone, brackets have been used to show how much of one group as a whole corresponds to how much of another. In these cases the particular horizons may or may not correspond to each other, the evidence being generally inconclusive on this point.

## TABLE OF CORRELATED HORIZONS.

### Muschelkalk and Upper Trias.

| Horizon of | E. of Guryul ravine, Khunmu. | Khrew. | Wean. | Pastannah. | Lám. | Narastán. | Mandakpál. |
|---|---|---|---|---|---|---|---|
| *Spiriferina* cf. *Haueri*, *S. Stracheyi* and lamellibranchs. | (4) 8-8-08<br>(3) Do.<br>(2) Do.<br>(1) Do. | (2) 15-9-09<br>(1) Do.<br>(3) 16-9-09 | (1) 14-8-05 | — | (1) 16-8-09<br>(1) 20-8-09 | (3) 25-8-09<br>(2) Do.<br>(1) Do. | — |
| *Ptychites* (*Megalodisci* group) and *Pseudomonotis*. | (7) 11-8-08<br>and near<br>(7) 11-8-08 | (2) 16-9-09 | — | (7) 30-8-09<br>(6) Do.<br>(5) Do.<br>(4) Do.<br>(3) Do. | | | |
| *Ceratites* sp. | — | (2½) 15-9-09 | — | (2) 30-8-09<br>(1) Do. | (6) 16-8-09<br>(5) Do.<br>(4) Do.<br>(3¼) Do.<br>(3¾) Do.<br>(3½) Do.<br>(3) Do. | — | — |
| *Rhynchonella trinodosi* and *R.* sp. | (6) 11-8-08 | (3) 15-9-09<br>(4) Do. | — | (1) 12-9-09 | | | |
| *Gymnites* and *Ceratites*, etc. | — | (1) 17-9-09<br>(2) Do. | — | (2) 27-8-09<br>(1) 8-9-09<br>and<br>(1) 27-8-09<br>(3) 3-9-09<br>(2) Do. | | | |
| — | — | — | — | (1) 3-9-09<br>(0) 27-8-09 | — | — | — |

## TABLE OF CORRELATED HORIZONS—*contd.*

### Lower Trias.

| Horizon of | E. of Guryul ravine, Khunmu. | Khrew. | Wean. | Pastannah. | Lám. | Narastán. | Mandakpál. |
|---|---|---|---|---|---|---|---|
| *Pseudomonotis*, etc. | — | — | — | — | (4) 20-8-09<br>(3) Do. | — | — |
| *Hungarites* (position uncertain). | — | — | — | (×) 4-9-09 | — | — | — |
| *Meekoceras* . | (4) 6-8-08<br>(3) Do.<br>(2) Do.<br>(1) Do. | — | — | — | — | (?) (2) 23-8-09. | (4) 14-8-08.<br>(3) Do. |
| *Ophiceras* . . | — | — | — | (1) 5-9-09 | — | — | — |

### Zéwan or Permo-Carboniferous.

| — | Golabgarh Pass. | Barus. | 2 miles N. of Barus. | Mandakpál. | Guryul Ravine. | Pastannah. | Lám and Narastán. |
|---|---|---|---|---|---|---|---|
| Lamellibranchs . | — | — | (3) 26-8-08<br>(4) Do. | — | — | — | — |
| *Spirifer Rajah* (predominant). | C | (1) 23-8-08 | Present (no number). | (1) 2-10-09 | — | (1) 11-9-09 | — |
| — | — | — | — | (2) 2-10-09 | — | — | — |
| *Spirifer Rajah, Marginifera, Productus Cora, Lyttonia*, etc. | B | — | (5) 26-8-08 | (3) 14-8-08 | — | — | — |
| *Productus semi-reticulatus.* | — | — | — | — | (1) 10-10-09 | — | (1) 23-8-09 |
| — | — | — | — | (1) 16-8-08<br>(2) Do. | (1) 2-8-08 | — | — |
| *Protoretepora ampla.* | Z. 2. | Present. | Present. | Present. | Present. | Absent. | Absent. |
| — | Z. 1. | (3) 24-8-08<br>(2) Do.<br>(1) Do. | — | — | (1) 4-8-08 | — | — |

## TABLE OF CORRELATED HORIZONS—*contd.*

### Lower Gondwana.

| Horizon. | Golabgarh Pass. | Pansapura. | Vihi district. |
|---|---|---|---|
| *Glossopteris* and *Vertebraria* . | X | (?) (1) 9-8-09 | — |
| *Gangamopteris* and *Psygmophyllum*. | W. 1. | | Present at Risin and Zéwan spurs. |

### Panjal Traps and Agglomeratic Slate (Unfossiliferous).

### Fenestella Series (Middle Carboniferous?).

| Horizon. | Lehindajjar. | Left bank Lidar R. S. S. E. of Dowhat. | Head of Kirram valley. | Buru. |
|---|---|---|---|---|
| Uppermost Fenestella bed . | (3) 27-5-09 | (1) 1-6-09 | — | — |
| "Camp" horizon . . . | (1) 26-5-09<br>(2) 23-5-09 | (2) 13-9-08<br>(3) Do.<br>(5) Do.<br>(4) Do.<br>(1) 6-9-08<br>(1) 6-6-09 | (1) 8-8-09 | (1) 13-5-09 |
| Lehindajjar bed . . . | (3) 24-5-09<br>(2) Do. | | | |

### Passage Beds.

### Syringothyris Limestone Series (Lower Carboniferous).

| — | Kotsu. | Eishmakám and neighbourhood. | N. W. of Paisau. |
|---|---|---|---|
| — | (2) 15-5-09<br>(2) 12-5-09 | (0) 3-9-08<br>(2) 3-9-08, (4) 5-9-08, (1) 14-6-09<br>(3) Do. (3) Do. (2) Do.<br>(3) Do. | (1) 27-6-09 (1) 4-7-09<br>(2) Do. |

## TABLE OF CORRELATED HORIZONS—*concld.*

### "Muth" Quartzite.

### Upper Silurian.

| — | Gugaldar. | Gudramer. | Margan Pass S. side. | Lutherwan. |
|---|---|---|---|---|
| — | (1) 19-6-09 | (1) 11-7-09 | (1) 21-7-09 | (1) 22-7-09 |

In conclusion, I should like to draw attention to the fine field which Kashmir offers to future explorers among Himalayan fossiliferous sedimentaries. In the vale of Kashmir, or within a few easy marches from the capital of the State, there are deposits of Silurian, Carboniferous and Trias age, comparable in many respects to those which occur in the classic regions of the Salt Range, Spiti, Garhwal and Kumaun. The last three places are, however, some weeks of arduous marches from railway and road, are only accessible with difficulty, and lie at elevations sometimes twice or even thrice that of the Kashmir areas. The Salt Range on the other hand lies at a low elevation, and cannot compare in climate with Kashmir, which also, as is well-known, is an ideal embodiment of the picturesque and beautiful.

There is only one drawback, and that is that one must dig, and dig very laboriously and continuously, before one obtains worthy representatives of the rich faunas that for so long have lain almost neglected.

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## LIST OF PLATES.

# NOTE ON THE DISCOVERY BY MR. MIDDLEMISS OF FENESTELLA-BEARING BEDS IN KASHMIR. BY H. H. HAYDEN, *Superintendent, Geological Survey of India.*

OF the many important discoveries made in recent years in Kashmir, those recorded by Mr. Middlemiss in the foregoing paper will probably prove to be the most far-reaching, since they throw a new light on what has been the most vexed question in the whole realm of Indian geology, the great Gondwana controversy, and may possibly compel us to revise our estimate of the age of the Talchir boulder-bed and of the fossiliferous horizons immediately overlying it. The object of the present note, however, is not to discuss the general bearings of the recent discoveries—a task which will no doubt be ably carried out by Mr. Middlemiss in due course —, but to draw attention to, and to correct, certain misapprehensions of my own.

The part of Mr. Middlemiss' paper which has an immediate bearing on the case is that comprised in pages 222 to 232, from which it will be seen that he has definitely proved the presence in several localities of certain beds containing *Fenestellæ,* and which he categorically identifies with the Fenestella shales of Spiti. In a paper published in 1904,[1] and in subsequent papers,[2] I have correlated the Spiti Fenestella Shales with the lower beds of the Zéwan stage, which are separated from Mr. Middlemiss' Fenestella beds by the whole thickness of the agglomeratic slate and the Panjal trap. This correlation was based on a description by Professor Diener[3] of certain fossils supposed to have been collected in beds of the Zéwan stage, but Mr. Middlemiss[4] has now shown that these fossils were a mixed lot derived partly from his Fenestella beds and partly from the true Zéwan stage and he has made out a very strong case for the correlation of the Fenestella shales of Spiti with the Fenestella beds of Kashmir. If this is correct, we have now to

[1] *Mem., Geol. Surv. India,* XXXVI, part i (1904).

[2] *Rec., Geol. Surv. India,* XXXVI, 35 (1907); Burrard and Hayden: *Geography and Geology of the Himalaya and Tibet,* 244 (1908).

[3] *Pal. Indica,* Sec. XV, Vol. 1, pt. 2.

[4] *Mem., Geol. Surv. India,* XXXVI, pt. 149 (1904).

look, in Spiti, for the equivalent of the lower part of the Zéwan stage with *Protoretepora ampla*. It is of course possible that there are two Fenestella horizons in Spiti, as indeed at first sight there appear to be on the left side of the Spiti river below Po, but on the whole the evidence is against this. The Productus shales of Spiti may be safely correlated with the similar beds of Kashmir, but we ought properly to restrict this term to the beds containing *Marginifera* and *Spirifer rajah*; the lower part of the Zéwan stage with *Protoretepora ampla* must then find its equivalent in Spiti either in the Calcareous sandstone stage or in the underlying conglomerate, or in both. One is certainly tempted to see in the great unconformity, which extends from Kumaun to Spiti, the equivalent of the break in continuity of marine sedimentation represented by the Panjal trap, in which case the Spiti conglomerate will after all approximate in age to the Talchir boulder-bed. And here I must cry "*peccavi*" in having dissented so emphatically from Mr. Oldham's correlation of these one with the other, and in fairness to him I must admit, with equal emphasis, that not only has the supposed evidence against this broken down but the new facts collected by Mr. Middlemiss are decidedly in its favour. This, however, refers only to the correlation of the Spiti conglomerate with the Talchir boulder-bed and that only from the point of view of homotaxis, not of mode of origin, for I still regard the Spiti rock as an ordinary conglomerate and quite distinct from a tillite; nor does this affect my views as to the age and relationships of the Blaini boulder-slate.[1]

In the light of Mr. Middlemiss' discoveries further study of the Po series of Spiti is highly desirable. It was only very cursorily examined by the late Dr. von Krafft and myself and may comprise fossiliferous horizons not yet found. So far *Protoretepora ampla* has only been observed in the Fenestella shales of Losar, but the persistence of this species in Kashmir as exemplified by its survival from the Fenestella beds up to the Zéwan stage, that is to say through a postulated glacial epoch[2] followed by one of undoubted volcanic activity is very striking. This can only be explained either by great hardiness

[1] Burrard and Hayden: *op. cit.* p. 228 (1908).

[2] Recent work has not adduced any evidence in favour of a glacial origin for the agglomeratic slate (Panjal conglomerate), which Mr. Middlemiss is evidently inclined to regard rather as of volcanic origin.

and stability of the species or else by re-immigration at the close of the volcanic period. The recurrence of this species, as well as that of one or more species of *Productus*, rather indicates that the Panjal volcanic period was of comparatively short duration, in spite of the great thickness of material poured out. In this case there may have been no great time-interval between the deposition of the Fenestella beds and that of the lowest beds of the Zéwan stage. We must look to Mr. Middlemiss for an answer to this question which has an important bearing on the age of the Talchir stage.

C.S. Middlemiss, Photo.

*G. S. I. Calcutta.*

PANJAL BEDDED TRAPS, N.E. OF GUGALDAR

GEOLOGICAL

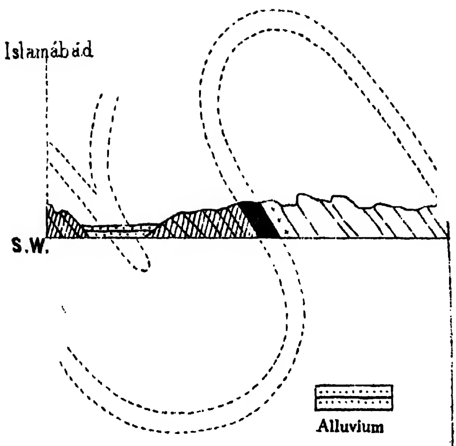


FIG. 1. SEC

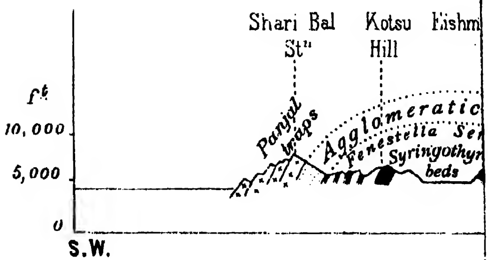


FIG. 2. LIDAR V

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On some Fish-remains from the Beds at Dongargaon, Central Provinces : Vol. III, Memoir No. 3 (1908), by A. Smith Woodward, pp. 6, pl. 1.
The Fossil Giraffidae of India . Vol III, Memoir No. 4 (*in the Press*), by G. E. Pilgrim.

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## Vol. IV, 1871.

*Part 1*—Annual report for 1870 Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.

*Part 2*—Axial group in Western Prome. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.

*Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.

*Part 4.*—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

## Vol. V, 1872.

*Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

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*Part 3.*—Maskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Prome. Geology of Bombay Presidency.

*Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eozoonal limestone of Yellam Bile.

VOL. VI, 1873.

*Part 1.*—Annual report for 1872. Geology of North-West Provinces.

*Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.

*Part 3.*—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanole field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.

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VOL. VII, 1874.

*Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolumyte. Geological notes on part of Northern Hazaribagh.

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*Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.

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VOL. VIII, 1875.

*Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talchir period. Trials of Raniganj fire-bricks.

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*Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

*Part 1 (out of print).*—Annual report for 1875. Geology of Sind.

*Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of Stegodon Ganesa, with notes on sub-genus and allied forms. Sub-Himalayan series in Jamu (Jammoo) Hills.

*Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidende they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian faunæ of India and Burma.

*Part 4.*—Fossil floras in India. Osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Plesiosaurus in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

*Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus Omphalia near Nameho lake, Tibet, about 75 miles north of Lhassa. Estheria in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

RECORDS OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1910. [ May.

# Geology and Prospects of Oil in Western Prome and Kama, Lower Burma (including Namayan, Padaung, Taungbogyi, and Ziaing). By Murray Stuart, B.Sc., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 23.)

**List of localities described below.**

THE localities described below include Namayan, Padaung, Ziaing, and Taungbogyi in western Prome, and Kama in western Thayetmyo (see Pl. 23). At each of these, oil seepage occurs or has occurred in recent years. All of these localities were mapped by W. Theobald in the years 1861—1873, but the scale of his map (8 inches=1 mile) was too small to permit of anything but the largest divisions being made.

**Rocks occurring in the district.**

The rocks occurring in the area mapped belong to the following series, described by Theobald in the *Memoirs, Geological Survey of India*, Vol. X [1] :—

Newer Alluvium. } Recent.
Older Alluvium. }
Irrawaddy series (" Fossil-wood group ").
Pegu system.
Nummulitic series.

[1] Page 39.

**Extent of detailed examination.**

So far as the older[1] and newer alluvium beds are concerned, I have merely mapped them where they occur to any extent, without any further examination, and have confined my detailed examination to the rocks of the Pegu system, especially with regard to its relations to the underlying Nummulitic series on the one hand and the overlying Irrawaddy[2] series on the other. I may mention here, however, that around Thingan there is a deposit of kankar, somewhat argillaceous and covering an area of some square miles, which corresponds to the Older Alluvium in other parts of the district. It has a gentle dip to the south and completely masks the underlying rocks. Where it is traversed by streams, the calcareous matter has been dissolved and redeposited in thick masses of non-argillaceous kankar. It is interesting in that it contradicts the view put forward by Theobald that such kankar deposits do not occur in Pegu (*Memoirs, Geological Survey of India*, Vol. X, part 3, page 46), and its occurrence brings the Older Alluvium of Pegu into closer similarity with that of India.

**Divisions of the Pegu series.**

At the same time I have mapped the rocks of the Pegu system itself in some detail, and have everywhere succeeded with little difficulty in distinguishing the subdivisions suggested by Theobald, *viz.* :—

4. Kama clays.
3. Upper Prome series (section B of Theobald).[3]
2. Lower Prome series (section A of Theobald).
1. Sitsayan shales.

**Theobald's section of the Upper Prome beds incomplete.**

I can add little or nothing to Theobald's detailed and admirable description of these rocks, except to confirm the suggestion of Noetling, that the rocks described in section B (Upper Prome series) do not comprise the whole of that division, but that there is a considerable thickness of these

[1] This older alluvium is the equivalent of the Red Alluvium Silt or Red Alluvium frequently referred to by other writers subsequent to Theobald.

[2] This is identical with the Fossil-wood group mentioned by Theobald.

[3] *Memoirs, Geol. Surv. Ind.*, Vol. X, pt. 3, p. 84.

beds hidden by the channel of the Irrawaddy at the point where Theobald's observations were taken.[1]

**Theobald's scheme of classification adopted in preference to Dr. Noetling's.**

It is my intention to adhere throughout the paper to Theobald's scheme of classification, as given above, in preference to Noetling's later scheme of classification which consisted of the 'Yenangyaungian' and 'Promeian,' and wherever in the subsequent pages I refer to Prome beds I mean the Prome beds of Theobald's classification and not the Promeian of Noetling. My reasons for preferring Theobald's scheme to that of Noetling I give on a later page in this paper.

**Real thickness of the Upper Prome series.**

The thickness of the Upper Prome beds where they occur by Thebyu, just to the north of Prome, where their full thickness is exposed, is in the neighbourhood of 2,200 feet.

**Stratigraphical position of the Kama clays.**

Leaving for the time the question of what beds occur over the Prome beds at this particular point, Theobald was perfectly correct in assuming that the Kama clays follow directly upon the Upper Prome series in the general section of the Pegu rocks.

**General structure of the district.**

The rocks of the district shown on the map speaking generally dip in a direction ranging from north-east to east, and have developed a subsidiary synclinal fold between Padaung and Ziaing. The main feature of the country is a large fault which runs in a N.N.W. direction, and passes through the mud volcanoes and salt springs indicated by Theobald.[2] Its effect is considerable, for at Thingan, Sitsayan shales on the east of the fault are faulted against Kama clays on the west, and similarly at Sinde the lowest beds of the Lower Prome series are faulted against beds high in the Kama clays. It is most probable that it is not a simple fault, but that it is combined with a horizontal movement of the beds west of it in a N.N.W. direction.

**Detailed structure west of the fault.**

West of this fault and north of Padaung there is a syncline and anticline of Pegu rocks: Kama clays occurring in the trough of the syncline and on the eastern flank of the anticline, while lower Prome beds are exposed along the crest of the anticline. To the

[1] *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 22.

[2] "Salt Springs of Pegu." *Records, Geol. Surv. Ind.*, Vol. VI, p.67.

north these folds are cut off by the fault, but to the south they end abruptly near Kayinzu, where the lowest beds of the Kama clays outcrop in the Irrawaddy dipping E.S.E. It is from these beds of the Kama clays that the oil seepage at Kayinzu used to occur, but the seepage is reported to have been exceedingly slight and has not been observed for several years.

**Detailed structure east of the fault.**

In the Prome beds opposite Prome and east of the fault this synclinal and anticlinal structure again occurs, but to a very much smaller extent, being confined to the Upper and Lower Prome series and only extending from Ziaing on the north to Kyaukthinmaw to the south. North and south of these places the rocks dip in a general easterly direction.

**Unconformity between the Pegu and Nummulitic series.**

On tracing the base of the Sitsayan shales over the sandstones and clays of the Nummulitic series, it became at once evident that they do not form a conformable sequence as hitherto supposed, but that a considerable unconformity occurs between the two groups; for, though the difference in direction and amount of dip was not apparent in any individual section, yet as I traced the junction from north to south I found that the Sitsayan shales overlap bed after bed of the Nummulitic series. Also the Sitsayan shales contain near their base occasional worn fragments of the Nummulitic sandstones and limestones.

**Direction of strike of the Nummulitic series.**

The general strike of the beds of the Nummulitic series is north-west, while the base of the Sitsayan shales traces an irregular line which has roughly a north and south direction. I made no attempt to measure the thickness of the Sitsayan shales, because no section occurred where such a proceeding was possible.

**Lower Prome series not unfossiliferous as hitherto supposed.**

Overlying the Sitsayan shales comes the Lower Prome series (section A of Theobald), by no means unfossiliferous as Noetling has assumed,[1] but containing no distinctive fossil horizons. Thus, from the massive sandstones at the base of the series, where they outcrop by Sinde village, I obtained abundant echinoderms and sharks' teeth.[2] The echinoderms being

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[1] *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 7.
[2] *Infra*, p. 292

in each case surrounded by ferruginous concretion, it was impossible to determine the species to which they belong. From the same bed I obtained the cephalothorax of a brachyurous crab measuring five inches in width, but the specimen does not admit of determination.

**Fossils from the Lower Prome series.**

About fifty feet below the top of this series of beds, that is to say, fifty feet below the bed containing *Cytherea erycina* which outcrops opposite Prome, there occurs a bed filled with *Turritella simplex*, Jenkins, and *Turritella acuticarinata*, Dunker. Therefore it is evident that these two *Turritellae* can no longer be considered as forming one of the highest zones in the Pegu beds,[1] as suggested by Noetling. Between this and the fish teeth zone I found an imperfect shell belonging to the *Conus* family. Where the Lower Prome series is exposed near Kama it is much more fossiliferous than is the case opposite Prome, the most frequent fossils being:—

*Flabellum distinctum*, Milne Edwards.
*Dione* sp.
*Turritella* sp.
*Vermetus javanus*, K. Martin.
*Ficula* sp., Noetling.[2]
*Conus* sp.

This is not intended to represent an exhaustive list of the fossils in the Lower Prome series, but is rather given to show that these beds are by no means unfossiliferous as assumed by Noetling. Nevertheless as a rule this series contains few fossils throughout the district mapped.

**The occurrence of *Cytherea erycina* in the Upper Prome series.**

Following these beds in normal sequence comes the Upper Prome series, of which the lowest 541 feet are described by Theobald in his section B.[3] These beds have for their base opposite Prome a bed containing abundant *Cytherea erycina*, Fav., and where their full development is seen near Thebyu are about 2,200 feet in thickness. At Kama a similar thickness of them is exposed, consisting of sandstones and shaly beds, crowded with fossils and containing *Cytherea erycina* in the greatest profusion from bottom to top. This of course destroys all value of *Cytherea erycina* as a zone

[1] See *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 26.
[2] *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 299.
[3] *Memoirs, Geol. Surv. Ind.*, Vol. X, pt. 3, p. 84.

fossil ; but it should be remembered, however, that the zone fossils constituting the basis of Noetling's nomenclature do not characterise exclusively the horizons named after them. In most cases the mollusca of the Pegu system range through a number of successive horizons, and Noetling's zones are named after certain forms which happened to be particularly abundant in certain beds of the sections he studied. The faunistic constitution of the zones is, however, to a great extent a matter of facies, and the reappearance of any particular form in another section at a distance from Noetling's type sections by no means signifies that they are on the same horizon. This applies particularly to forms such as *Cytherea erycina*, Fav., which are regarded as identical with shells that are still living. If the zone names used by Noetling are retained, it should be kept in mind that they must be taken to indicate the same horizons as in the original scheme, irrespective of the exact faunistic constitution at any particular locality.

**Character of the Upper Prome series, and discovery of a Gaj fossil in the top beds.**

The general character of the Upper Prome series, which consists of alternations of massive and shaly sandstones and shales, is softer than that of the Lower Prome series ; the outcrops are characterised by lower hills than those formed by the beds of the Lower Prome series. In fact the two divisions can generally be distinguished throughout the district by the difference in the physical features of their outcrops. The uppermost beds of this series form the zone of *Parallelipipedum prototortuosum* described by Noetling. This year, Mr. H. J. Davies, Geologist to the Burma Oil Company, has discovered at the top of this series a bed crowded with *Ostrea*, which were immediately recognized by Mr. E. Vredenburg as being *Ostrea latimarginata*, Vred., thus giving a parallel horizon with the Gaj in Sind, in Persia, in Cutch, and in Kathiawar.

***Turritella* sp. from the top of the Upper Prome series.**

I have this year found in these topmost beds of the Upper Prome series a species of *Turritella* which is different from any hitherto described from the Burmese tertiaries. It is characterised by three sharp revolving keels, of almost equal strength, which seem to persist up to the embryonic whorls. From the figures and description given by K. Martin in his " Die fossilien von Java " it seems to be comparable with *Turritella djadjariensis*, Mart. It has also been found by Mr. Davies in his zone of *Ostrea latimarginata*, Vred., and seems to occur in the topmost beds of the Upper Prome series and possibly the basal beds of the Kama clays.

**Kama clays.**

Above these beds follows a series of shales with sandy beds and occasional sandstones, which are the Kama clays mentioned by Theobald. These beds are crowded with fossils, of which perhaps the most important is *Arca theobaldi*, Noetling, which occurs near the base and forms the zone of that name described by Noetling.

**All the oil seepages in the district from Kama clays.**

This top division is the most important of all the divisions of the Pegu beds from an economic point of view, because it is from it that all the oil seepages reported in the district occur, thus contradicting Noetling's theory that the oil-bearing strata were all in his Promeian division, *i.e.*, the Lower Prome series and the Sitsayan shales. The exudation of gas at Kama comes from these Kama clays; the oil seepage near Thingan comes from them close to where they are cut off by the fault; the seepage at Kayinzu comes from the very base of these beds, while the seepage at Namayan cannot come from beds older than these clays.

**Fossils from the Kama clays.**

The fossils occurring in these clays at Kama have already been described by Noetling in his memoir.[1] Where they out-crop near Thingan, I obtained the following:—

*Dendrophyllium* sp.,
*Dione* sp.,
*Turritella acuticarinata*, Dunker,
*Vermetus javanus*, K. Martin,
*Marginella (Glabella) scripta*, Reeve,
*Genota irravadica*, Noetling;

while from a similar horizon near Thebyu I obtained :—

*Arca* sp.,
*Leda virgo*, K. Martin,
*Dione* sp.,
*Corbula socialis*, K. Martin,
*Marginella (Glabella) scripta*, Reeve,
*Pleurotoma karenaica*, Noetling,
*Conus avaensis*, Noetling.

[1] Zone of *Arca theobaldi*.

**Marine beds which overlie the Kama clays, west of the Irrawaddy.**

Having described these beds, it remains now to deal with the beds that overlie the Kama clays. While mapping in the neighbourhood of Padaung, I was much puzzled by some beds which formed a marked ridge at Tamagon, and there seemed to lie conformably upon the Upper Prome series, but which when traced northwards swing unconformably across the Kama clays and are cut off by the fault. They consist of coarse yellow grits and occasional conglomerates, more or less ferruginous, and yellow sands. They contain marine fossils, most of which occur in the Pegu rocks, but are characterised by the abundance of *Ostrea* among the forms.

**Marine beds which overlie the Kama clays, east of the Irrawaddy.**

A small patch of these rocks is exposed in the trough of the syncline near Myaungshe, and also on the eastern shore of the Irrawaddy at Namayan. It was not, however, until I worked north of Prome that the age of these rocks became clear. In the stream near Thebyu the topmost beds of the Lower Prome series are exposed. Overlying these follows the whole series of the Upper Prome beds, and over these again lie the Kama clays, of which about 1,200 feet are seen. Over these Kama clays is a series of grits and sandstones, containing marine fossils: these beds are the exact counterpart of the Tamagon beds. They pass upwards into yellow sandstones with few fossils and these in turn are covered up and concealed by a thick deposit of the gravels of the older alluvium..

**Unconformity between Kama clays and overlying marine grits.**

As the junction of the grits and the Kama clays is traced southwards, it becomes apparent that these grits are lying unconformably across the clays, and are creeping more and more across their outcrop towards the top of the Upper Prome series. The actual spot where these grits do actually overlap and conceal the Kama clays is not visible, but is somewhere in the channel of the Irrawaddy opposite Prome.

**Marine beds above unconformity pass conformably into beds of Irrawaddy series.**

The beds at Prome described by Theobald as the upper members of the Pegu group, and as passing conformably upwards into the Irrawaddy series, are these grits and sandstones which are lying unconformably upon Kama clays and Upper Prome beds.

South of Prome these basal grits are seen in the Mauchaung stream to be lying directly upon the Upper Prome series.

**Marine beds must be classed in the Irrawaddy series.**

In view of this unconformity and the absolute difference of their lithological character from that displayed by the rocks of the Pegu series it is impossible to class them with that system, but they must of necessity be classed with the beds of the Irrawaddy series, with which they are apparently quite conformable, and with which they agree much more closely in lithological character.

**Theobald's Mogoung sands.**

In the *Records of the Geological Survey of India*, Vol. 2, part 4, Theobald divides his Fossil-wood group (since called Irrawaddy series) into three divisions, naming the lowest division the Mogoung sands which he describes as follows :—

"Mogoung sands.

A mixed assemblage of shales, sands and conglomerates, the last very subordinate,................Towards the base the beds contain marine shells and pass into those of the next group."

**Mogoung sands identical with marine beds at base of Irrawaddy series.**

These marine grits which I have described as lying unconformably upon the Kama clays and Upper Prome series undoubtedly correspond to the lowest and marine beds of Theobald's Mogoung sands. The beds themselves are of little importance, save that they show that it is unsafe to class a post-nummulitic rock containing marine fossils as belonging to the Pegu group without referring it to known beds of that group.

**Impossibility of determining Pegu beds by working from Irrawaddy series.**

Another point which this unconformity emphasises is the impossibility of finding the horizon of any definite bed in the Pegu system by working down from the base of the overlying Irrawaddy series; yet this seems to have been the procedure adopted by Noetling in fixing the position of the Lower Prome beds at Yenangyaung.[1]

**Noetling's scheme of classification unsuitable.**

It will have been noticed that throughout this report I have carefully adhered to Theobald's divisions, merely calling his B and A sections of the Prome beds, Upper and Lower Prome series. I have carefully avoided using the divisions suggested by

[1] *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 29.

Noetling, *viz.*, Yenangyaungian (consisting of the Kama clays and Upper Prome series) and Promeian (consisting of the Lower Prome series and Sitsayan shales), because I think they are totally unsuitable both as names and as divisions.

**No evidence that Lower Prome series outcrops in the Yenangyaung oil-field.**

At Yenangyaung a series of Pegu shales and sands is exposed under the beds of the Irrawaddy series, and we have at present no evidence, structural or palæontological, that any part of these shales and sands may be on the same horizon or the equivalent of the hard massive sandstones of the Lower Prome series (the Upper division of Noetling's Promeian) exposed in Lower Burma. On the other hand I shall show in a subsequent paper[1] that it is most probable that all the Yenangyaung shales and sands overlie the Upper Prome series, that they are in fact the upper development of the Kama clays, which is obliterated in Lower Burma by the overlap of the Fossil-wood group. The difference of the Yenangyaung fauna from that existing in other places would fall in with this view. Be that as it may, I think it better at present to adhere to the terms Upper and Lower Prome series and to keep the Kama clays and Sitsayan shales distinct and separate, than to class the Lower Prome series and Sitsayan shales together as Upper and Lower Promeian, and the Kama clays and Upper Prome series as Upper and Lower Yenangyaungian. Such a division of the Pegu system has nothing to recommend it, whereas the Upper and Lower Prome series have similar lithological characters and fall naturally into one division, and the Sitsayan shales on the one hand and the Kama clays on the other have no characters in common with them, but must necessarily form divisions by themselves.

## Summary.

The points adduced in the foregoing paper which are contrary to the views held hitherto are the following :—

1. Theobald's detailed description of the Upper Prome series does not comprise the whole of it, but only the base of the series.
2. The Pegu and Nummulitic systems do not form an unbroken sequence ; on the contrary there is a distinct unconformity between the two.

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1 *Infra*, p. 290.

3. The Lower Prome series is by no means unfossiliferous as has been hitherto supposed.[1]
4. The two forms, *Turritella simplex*, Jenkins, and *Turritella acuticarinata*, Dunker, can no longer be regarded as forming one of the highest zones in the Pegu system. They occur similarly in the Lower Prome series.
5. *Cytherea erycina*, Fav., occurs in the greatest profusion throughout the Upper Prome series.
6. The oil-bearing strata of the district are the Kama clays (the topmost division of Noetling's Yenangyaungian) and not either the Lower Prome series or the Sitsayan shales (which comprise Noetling's Promeian), hitherto supposed to be the oil-bearing strata.
7. The Kama clays are the topmost beds of the Pegu system in the district, which is contrary to what Theobald assumed.
8. There is a distinct unconformity between the Pegu and Irrawaddy systems.
9. The basal beds of the Irrawaddy system are marine throughout the district; which last two facts are contrary to the former idea that the two systems were perfectly conformable and that the Irrawaddy system did not contain any marine beds.
10. Noetling's scheme of classification of the Pegu system into Yenangyaungian and Promeian is not suitable for the subdivision of the system, which is more satisfactorily effected by Theobald's scheme.

## Prospects of Oil.

*Padaung.*—The oil seepage in this locality comes from the base of the Kama clays where they outcrop in the bed of the Irrawaddy by Kayinzu. The only anticline in the neighbourhood runs N.N.W. from Kayinzu and has Lower Prome beds exposed along its crest. Since there is no evidence of oil in the Pegu series below the base of the Kama clays a boring in the anticline would probably not pass through any oil-bearing strata.

[1] Mr. L. Dalton claims to have found fossils in these rocks (*Quar. Journ. Geol. Soc.*, Vol. LXIV, p. 608), but it will be seen below (p. 274) that the horizon from which the fossils were obtained is really the equivalent of the Kama clays and not of the Lower Prome series.

*Ziaing.*—The remarks which I have made above apply in this case also. The oil seepage occurs from the Kama clays near Thingan and close to the fault. It occurs on about the same horizon as the seepage at Kayinzu. The only anticline in the vicinity is the one mentioned as stretching N.N.W. from Kayinzu, which is cut off by the fault near Thingan and contains no oil-bearing strata.

*Namayan.*—The horizon of the oil seepage here is a little more obscure, since the rocks are covered with alluvium to the west of the fault. The seepage occurs on the line of the fault and apparently comes from the beds on the west of it. These beds, from the general trend of the strata across the river, cannot be older than Kama clays. There is no anticlinal structure and it is useless to prospect for oil in the vicinity.

*Taungbogyi.*—The oil seepage used to occur here in some sandstones dipping steeply to the north-east. The beds belong to a series which contain Eocene *Orbitoides* and in its upper members Eocene nummulites. They are undoubtedly of Eocene age and are overlapped unconformably by the Sitsayan shales. There is no anticlinal structure in the vicinity. A boring was put down some years ago which failed to obtain oil at any depth, but encountered much water. Since that time all show or indication of oil has ceased. It is useless to prospect further here.

*Kama.*—Oil is reported here from a place south of the town where the base of the Kama clays outcrop, but as all the rocks are dipping steadily eastwards without any anticlinal structure oil cannot be expected in any quantity.

# THE RECORRELATION OF THE PEGU SYSTEM IN BURMA WITH NOTES ON THE HORIZON OF THE OIL-BEARING STRATA (INCLUDING THE GEOLOGY OF PADAUKPIN, BANBYIN AND AUKMANEIN). BY MURRAY STUART, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 24.)

**Localities.**

THE localities described below are Padaukpin, Banbyin, and Aukmanein in western Thayetmyo, in each of which oil seepages occur. The country around Padaukpin and Banbyin has been repeatedly examined by the geologists and experts of the Burma Oil Company and a short chapter is devoted to it in a paper on the Geology of Burma recently read before the Geological Society by Mr. L. V. Dalton.[1] The country around Aukmanein (Pl. 24) has now been examined in detail for the first time.

**Rocks outcropping near Aukmanein, and unfavourable prospects for oil.**

The rocks outcropping near Aukmanein belong to the Lower and Upper Prome series (having the same lithological characters as at Prome) and the Kama clays of the Pegu system.[2] Oil seepage occurs from the Kama clays near Aukmanein in the wet months, but since all the rocks are dipping eastwards at about 45°, the structure is very unfavourable for them to yield oil in quantity.

**Beds which overlie the Kama clays.**

Above the Kama clays come the massive yellow and grey sandstones described by Theobald in the *Memoirs of the Geological Survey of India*, Vol. X, part 3, page 93. These sandstones, which seem to lie conformably upon the Kama clays when seen in any individual section, are found, on tracing their outcrop, to overlap the Kama clays unconformably and are obviously the equivalent of the basal marine beds of the Irrawaddy series already described by me in the preceding paper as existing around

1 *Quar. Journ. Geol. Soc.*, Vol. LXIV, pt. 4.

2 The term Prome series refers to Theobald's scheme of classification, not to Noetling's (see previous paper).

Prome.[1] As in the Prome district these beds contain marine fossils and pass conformably upwards into undoubted beds of the Irrawaddy series.

Theobald describes these beds as follows:—

**Theobald's description of the rock of the locality.**

"West and South-west of Thaietmio stretches a belt of low hills, much scored by ravines and made up of the fossil-wood beds already described. The axis of this belt of country runs in a slightly curved line, with its concavity facing the river, from the village of Pima-khon, fourteen miles West-north-west from Thaietmio to Alayua, midway between Pulo and Kama, giving a length to this tract of twenty-five miles, by a breadth varying from six to ten miles. Leaving this belt of ground in a Westerly direction across the Pani (Punnee) strêam, the character of the country gradually changes in accordance with the fact of our descending somewhat on to the lower beds, beneath the fossil-wood group. Across the Pani stream in place of the incoherent fossil-wood sands, we come on to not very dissimilar beds, but in which marine fossils are pretty common: and which, from the abundance in spots of that shell, may be termed *Turritella* sands;" (It will be remembered that Theobald found these fossils in abundance in these beds at Prome.—M. S.) "and these beds are either very high in the series of the Prome group, or perhaps correspond in part with the Mogoung sands intervening between the Prome and fossil-wood groups."

**The structure of the country between Nathe and Aukmanein.**

These marine beds pass upwards conformably into the typical beds of the Irrawaddy series and are then much covered and obscured by the gravels of the Older Alluvium. Up to the point where they pass under the Older Alluvium their dip is steadily east-north-east at about 30°, but when, near Nathe, they again outcrop they dip at about 10° in a west-south-west direction.

**Fossil palm roots in the marine beds.**

Here, in addition to marine fossils, they contain the fossil roots of a species of palm tree. One such fossil root which I examined had numerous sharks' teeth embedded in the coarse grits which existed between the rootlets. Obviously, therefore,

[1] *Supra*, p. 266.

the marine conditions were rapidly giving place to shallow water and estuarine conditions.

**Kama clays outcrop at Padaukpin and Banbyin.**

Eastwards from Nathe, successively lower and lower beds outcrop, until, near Padaukpin and Banbyin, the Kama clays of the underlying Pegu system appear, being exposed, generally, along the streams, where these have cut down through the gently dipping beds of the Irrawaddy series. It is in these clays that the oil occurs.

**Anticlinal structure in the Irrawaddy series.**

Further to the east the beds of the Irrawaddy series bend over and dip sharply east-north-east at about 65°, forming another syncline between here and the Myinbataung ridge to the east. The general structure, therefore, is that of a subsidiary anticline developed in the trough of a large syncline.

**The locality not likely to prove productive in oil.**

I do not think that the locality is likely to prove productive of oil because of the unconformity between the overlying Irrawaddy sandstones and the underlying Kama clays: for although there is a somewhat definite anticline in the Irrawaddy beds, yet there does not seem to be any very definite anticlinal structure in the underlying Kama clays, which show subordinate puckerings rather than any very definite anticline.

**Fossils from the Kama clays at Padaukpin and Banbyin.**

From the clays where they outcrop near Banbyin and Padaukpin I obtained the following fossils:—

*Lithodomus* sp.
*Leda virgo*, K. Martin.
*Corbula socialis*, K. Martin.
*Turritella acuticarinata*, Dunker.
*Natica obscura*, Sowerby.
*Cerithium* sp.
*Ficula* sp., Noetling.
*Balanus tintinnabulum*, Linné.
*Hemipristis serra*, Agassiz.

**Fossils in the marine beds of the Irrawaddy series.**

The overlying marine beds of the Irrawaddy series contain many fossils, including frequent *Turritella acuticarinata*, as they do where they outcrop near Aukmanein.

**The basal bed of the Irrawaddy series wrongly correlated.**

In the paper on the Geology of Burma which I have previously mentioned as appearing in the *Quarterly Journal of the Geological Society*, Vol. LXIV, part 4, the author erroneously describes the bottom bed of this group, where it overlies the Kama clays near Padaukpin, as the zone of *Cytherea erycina*, both because of the discovery in it of "a species of *Conus* and a poorly-preserved *Ceratotrochus* (possibly *C. alcockianus*)," and from the fact that oil occurred below this horizon, being misled in this instance by Noetling's view that oil always occurs below the zone of *Cytherea erycina* and not above it. It was from the Kama clays beneath these sandstones that he discovered a fossil which he regards as identical with the European form *Lucina globulosa*; but the value of the discovery was considerably diminished by the fact that the horizon in which it occurred was at that time not correctly determined. Where the Pegu series outcrops at the edge of the main syncline near Aukmanein, the Upper and Lower Prome series have practically the same lithological characters as at Prome, forming steep hills running to 1,400 feet in height; it is, therefore, unlikely that they have changed their character so completely in ten miles or so as to be here represented by shales.

**Age of the Kama clays at Padaukpin.**

The discovery of *Lucina globulosa* in the top of these shales, immediately underneath the unconformity, definitely fixes the horizon as of Helvetian-Tortonian age, since this fossil is characteristic of that horizon in Europe, while the base of the Kama clays is a known horizon because of the occurrence of the band of *Ostrea latimarginata*, which, as stated in the preceding paper, occurs at the top of the Upper Prome series.[1] The evidence given by the form *Lucina globulosa* is supported by the occurrence of the tooth *Hemipristis serra*, Ag., also, which is characteristic of Miocene and Pliocene age.[2] Both of these pieces of evidence are seen to be of the greatest importance, in the light of the discovery of *Ostrea latimarginata* by Mr. H. J. Davies.

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[1] Page 264.

[2] See the next paper, p. 293.

I am indebted to Mr. E. Vredenburg for the following information as to the horizon of *Ostrea latimarginata* :—

**Age of beds with *Ostrea latimarginata* Vred.**

"This *Ostrea latimarginata* is the most characteristic fossil of the uppermost zone of the Gaj in Sind, in Persia, in Cutch, and in Kathiawar. The Gaj in Sind contains large lepidocyclines of the group *L. marginata* and cannot be newer than Upper Aquitanian. It is just possible that the uppermost zone with *Ostrea latimarginata* may be Burdigalian."[1]

**Thickness of Kama clays at Padaukpin very great.**

Consequently, the thickness of the Kama clays existing at Padaukpin and Banbyin represents the whole of the Burdigalian and at least the lower portion of the Middle Miocene as represented by Helvetian-Tortonian beds. Even without the fossils it is at once evident that a large thickness of beds of age newer than the basement beds of the Kama clays must exist here as a result of the unconformity.

**Structural evidence indicates the same deductions.**

At Aukmanein (see section, plate 24) the beds of the Irrawaddy series are dipping at about 30°, while the underlying Pegu group is dipping from 40° to 45° eastwards. This difference of dip is practically the same at Banbyin. Near Nathe the beds of the Irrawaddy series are dipping about 10° S.W., while the clays underneath are approximately horizontal, and further to the east where the beds dip eastwards the shales are dipping at angles from 70° to 80°, while the overlying sandstones are dipping from 60° to 70° (see section on plate 24). The underlying shales show subordinate puckerings, but, allowing fully for this, the thickness of the shales at Padaukpin and Banbyin must be very considerable compared with the thickness exposed at Aukmanein. The fauna, too, which is seen at Padaukpin and Banbyin is different in many respects from that seen in the Kama clays, which lie close above the Prome beds; but much stress cannot be laid upon this, because the occurrence of fossils at any place indicates that conditions were suitable for their deposition at that place, rather than indicating a definite horizon which may be recognized at some other point.

[1] See note on occurrence of *Ostrea latimarginata* on pages 127—132 of this volume of the *Records*.

**Probability of the structure of the oilfields being the same as that at Padaukpin.**

Since it is established that there is here a large thickness of Kama clays existing below the Irrawaddy series, I have little doubt that the different oilfields are a repetition of such structure, and the different fossils found in them are explained by the fact that different horizons of these shales are exposed in almost each oilfield; the thickness of shales existing in any individual field depends on the distance that oilfield is situated from the western boundary of the syncline where the Pegu beds outcrop, and also on the difference in the dip of the beds of the overlying Irrawaddy series and the shales throughout that distance.

**No evidence that oil occurs in the Pegu system below the Kama clays.**

Except in the oilfields we have no evidence that oil sands occur in the Pegu system below the base of the Kama clays. Even in the oilfields the only evidence we have is that given by Noetling's identification of beds of the age of the Lower Prome series (which form the upper division of this Promeian). This identification is not supported by any structural evidence. Indeed, in view of the big unconformity which I have shown to exist between the Irrawaddy and Pegu systems, and the structure of the Padaukpin area especially, the structural evidence contradicts rather than supports such a correlation. It is even more strongly contradicted by the fossil evidence. The fauna of the different oilfields is distinctly different from that of the Upper or Lower Prome series, and it will be shown on a later page that there is every reason to believe that the rocks exposed in the various oilfields are high in the Miocene system, whereas the base of the Kama clays as indicated by the discovery of *Ostrea latimarginata*, Vred., is lowermost miocene. That being so, it is safe to say that we have no definite evidence that oil sands occur in the Pegu system below the base of the Kama clays,[1] and consequently, as is the case in the Western Prome district, the idea put forward by Noetling that the oil must exist in the Lower Prome series and Sitsayan shales (Noetling's Promeian) is so far not justified. On the other hand the Kama clays (and here I mean the whole of the series of sands and clays intervening between the top of the Upper Prome series and the base of the Irrawaddy series) seem generally to contain oil throughout.

[1] Compare the evidence given in the preceding paper.

**Unconformity very small at Yenangyaung; hence Kama clays more fully developed.**

At Yenangyaung the development of the Kama clays seems to be even greater than at Padaukpin and Banbyin, and the existence of a terrestrial fauna (Noetling's zone of *Anoplotherium birmanicum*) seems to show that conditions were more nearly approaching the terrestrial conditions indicated by what are recognized there as the lowest beds of the Irrawaddy series: in other words, that the interval represented by the unconformity between the two systems is not so great there as it is at Padaukpin. The existence of the forms *Cyrena crawfurdi*, Noetling, and *Cyrena (Batissa) petrolei*, Noetling, both in the top beds of the Pegu shales and the basal conglomerate of the Irrawaddy series,[1] lends additional support to this view.

**The fauna of the basal beds of the Irrawaddy series at Yenangyaung.**

Dr. G. E. Pilgrim has kindly supplied me with the following information as to the horizon of the lowest beds of the Irrawaddy series at Yenangyaung:—

"I have examined the vertebrate fossils collected by Noetling in 1892 and by Grimes in 1897 from the lowest beds of the Irrawaddy series at Yenangyaung. They include—

*Mastodon latidens*, Clift.,
*Aceratherium perimense*, Lyd.,
*Hipparion punjabiense*, Lyd.,
*Tetraconodon* sp.,
*Potamochoerus titan*, Lyd.,
*Hippopotamus irrawadicus*, F. & C.,
*Merycopotamus dissimilis*, F. & C.,
*Boselaphus* sp.,
*Cervus* sp.

**Age of the basal beds of the Irrawaddy series at Yenangyaung.**

"This fauna is sufficient to fix the horizon of these beds definitely as Middle Siwalik, that is to say, as older than that of the fauna of the Siwalik hills and newer than that of the Lower Siwaliks of Sind and the Punjab. As nearly as possible this stage corresponds to the Pontian of Europe.

**Noetling's determination *Anopelothrium birmanicum* revised.**

"Noetling also collected two teeth from the marine beds of the Pegu series at Yenangyaung which he figured in *Pal. Ind.*, New Series, Vol. I, plate XXV, figs. 24 and 25. under the name *Anoplotherium birmanicum*.

[1] *Memoirs, Geol. Surv. Ind.*, XXVII, pt. 2, pp. 58—60.

Apart from the poor preservation of the specimens, their particular character does not admit of any exact determination. I may, however, say that I am unable to refer either of them to *Anoplotherium ;* one is an upper molar of a small sized and primitive member of the *Tragulidæ*, and the other is a lower molar of a selenodont suine animal allied to *Choeromeryx*. Another lower molar collected by Mr. Cunningham Craig from what would seem to be a similar horizon is allied to the last mentioned of Noetling's specimens although a different species. The specimens, while indicating that the beds in which they occur are newer than Aquitanian, admit of any age between that and Pontian."

**Age of the unconformity in Lower Burma.**

In Lower Burma the basal beds of the Irrawaddy series are, as I have already explained, marine, and are separated by an unconformity from purely marine beds of the Pegu series. That is to say, the conditions both before and after the unconformity were marine, passing upwards in later Irrawaddy times to estuarine and fresh-water conditions. The age of the unconformity has been fixed as post Helvetian-Tortonian by the previously mentioned discovery of *Lucina globulosa* below it, and it is probable that the unconformity is of Upper Tortonian age.

**Unconformity practically absent in Upper Burma.**

In Upper Burma and Yenangyaung the unconformity seems to be very small or absent, practically the whole series of beds being present; the first sign of the upheaval, marked by the unconformity in Lower Burma, is the occurrence of a fresh-water series of beds represented by Noetling's so-called zone of *Anoplotherium birmanicum*. This is followed by the marine beds mentioned by Mr. Pascoe (*Records, Geol. Surv. Ind.*, Vol. XXXVI, 1908, p. 135) which would correspond with the subsidence in Lower Burma which established the marine conditions prevailing there in earliest Irrawaddy times. These marine beds at Yenangyaung pass upwards into mixed beds containing few fossils except *Batissa*, and also much selenite and fossil-wood; these pass upwards into the fresh-water series, which has hitherto been classed as the Irrawaddy series at Yenangyaung, having the 'Red bed' for its base, and being Pontian and Younger in age.

**Classification of the beds which correspond to the unconformity of Lower Burma.**

It seems, therefore, that the so-called zone of *Anoplotherium birmanicum* is the equivalent of the unconformity in Lower Burma, and that the very slight unconformity between the 'Red bed' and those below it is

purely local in character, as has always been maintained by Mr. Pascoe. That is to say, the mixed series of beds down to the lowest fresh-water deposit, which have hitherto been classed as topmost Pegu, should be referred to the base of the Irrawaddy series; the Pontian age of the Red bed agrees certainly with the assignment of the so-called zone of *Anoplotherium birmanicum* (1,206 feet below the "Red bed") to the horizon of the unconformity in Lower Burma (of Upper Tortonian age). I believe Mr. Cunningham Craig, from the study of the volcanic rocks in Pakokku last year, came to the conclusion that the white bed (containing kaolin) which immediately underlies the Red bed at Yenangyaung could not possibly be the base of the Irrawaddy series, but must occupy a position some distance above the base. If this is so, it supports strongly the view deduced by me above from the study of the geology of Lower Burma. In any case it is impossible at present to correlate the marine basal beds of the Irrawaddy series in Lower Burma with the 'Red bed' in Upper Burma, and their true position cannot definitely be fixed without further examination.

**Correlation with European development.**

So far as is at present known, therefore, the correlation of the rocks discussed in this paper with the European scale is as follows:—

| Age. | Europe. | Burma. |
|---|---|---|
| Upper Miocene | Pontian | Lowest beds of the Irrawaddy series with mammalian bones. (Marine beds uncertain.) |
| Middle Miocene | Sarmatian<br>Tortonian<br>Helvetian | Unconformity.<br>Kama clays (petroleum-bearing strata). |
| Lower Miocene | Burdigalian | Ditto. (PEGU SYSTEM.) |
| Oligocene | Aquitanian<br>Stampian<br>Tongrian | Upper Prome series.<br>Lower Prome series.<br>Sitsayan shales.<br>Unconformity. |
| Eocene | .... | Nummulitics. (BASSEIN SYSTEM). |

**Main oil-bearing strata, Miocene.**

That is to say, the Kama clays, which seem to be the main oil-bearing strata, represent the Lower and at least part of the Middle Miocene of Europe, while the Prome series and Sitsayan shales, being earlier than lowermost Miocene and also post-Eocene, must be of Oligocene age.

**Fossil evidence of age of Pegu rocks in the various oilfields.**

Before closing this report I wish to review the fossil evidence at present known and to see how far it agrees with the evidence given in the previous pages that the shale series exposed in the different oilfields is really the upper development of the Kama clays seen in Prome.

**The known zones of the Pegu system.**

So far as is definitely known there are three fossil zones of fixed horizon :—

The zone of *Arca theobaldi*, situated at the base of the Kama clays.

The zone of *Parallelipipedum prototortuosum*, situated at the top of the Upper Prome series.

The zone of *Cytherea erycina*, situated at the base of the Upper Prome series.

**Zones of *Aricia humerosa* and *Pholas orientalis*.**

Between these lower two zones there are probably two more zones, *Aricia humerosa* and *Pholas orientalis*, but the exact position of these is not known.[1]

**Distribution of the oil-field fossils through the known zones.**

On studying the distribution of the fossils found in the above zones in the various oilfields, it is at once noticeable that the greatest number of forms are common to the zone of *Arca theobaldi*, while few are known in the lowest zone of *Cytherea erycina*, which is at the very base of Noetling's "Yenangyaungian."

On the other hand there are a large number of forms present which are not known in any of the known zones enumerated above.

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[1] *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 31.

The following tables, compiled from Noetling's table showing the vertical distribution of the fossils, will make this evident [1] :—

## Zone of *Mytilus nicobaricus* (Singu).

| — | Zone of Cytherea erycina (21 forms). | Zone of Arca humerosa (31 forms). | Zone of Pholas orientalis (28 forms). | Zone of Paral. prototort. (63 forms). | Zone of Arca theobaldi (58 forms). | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Paracyathus caeruleus, Duncan | .. | .. | .. | * | * | .. |
| Lima protosquamosa, Noet. | .. | .. | .. | .. | .. | * |
| Pecten irravadicus, Noet. | .. | .. | .. | .. | .. | * |
| Vulsella lingua-tigris, Noet. | .. | .. | .. | * | .. | .. |
| Mytilus nicobaricus, Reeve | .. | .. | .. | .. | .. | * |
| Modiola buddhaica, Noet. | .. | .. | .. | .. | .. | * |
| ,, pseudobuddhaica, Noet. | .. | .. | .. | .. | .. | * |
| Arca bistrigata, Dunker | .. | .. | .. | .. | .. | * |
| Cardita vaquesneli, d'Archaic & Haime | .. | * | .. | * | .. | .. |
| ,, planicosta, Noet. | .. | * | * | .. | .. | .. |
| ,, cf. mutabilis, d'Arch. & Haime | .. | .. | .. | . | .. | * |
| Crassatella dieneri, Noet. | .. | .. | .. | .. | .. | * |
| Cardium minbuense, Noet. | .. | * | .. | * | .. | .. |
| Meiocardia metavulgaris, Noet. | .. | .. | .. | .. | .. | * |
| Dione protolilacina, Noet. | * | .. | * | * | * | .. |
| ,, amygdaloides, Noet. | .. | * | * | * | * | .. |
| ,, protophilippinarum, Noet. | * | * | * | * | * | .. |
| Tellina grimesi, Noet. | * | * | * | * | * | .. |
| Gari deuterokingi, Noet. | .. | .. | .. | .. | .. | * |
| Corbula rugosa, Sowerby | .. | .. | .. | .. | .. | * |
| Dentalium junghuhni, K. Martin | * | .. | .. | * | .. | .. |
| Calliostoma blanfordi, Noet. | .. | .. | .. | .. | .. | * |
| Basilissa lorioliana, Noet. | .. | .. | .. | .. | * | .. |
| Solarium maximum, Philippi | .. | .. | .. | * | * | . |
| Turritella simplex, Jenkins | .. | .. | .. | * | * | .. |
| Siliquaria sp. | .. | .. | .. | .. | .. | * |

[1] *Pal. Ind.*, New Series, Vol. I, pt. 3, pp. 39–46.

## Zone of *Mytilus nicobaricus* (Singu)—*contd.*

| — | Zone of Cytherea erycina (21 forms). | Zone of Aricia humerosa (31 forms). | Zone of Pholas orientalis (23 forms). | Zone of Paral. prototort (63 forms). | Zone of Arca theobaldi (53 forms). | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Calyptraea rugosa, Noet. | .. | * | * | .. | * | .. |
| Natica obscura, Sowerby | * | * | * | * | * | .. |
| Sigaretus neritoideus, Linné | * | .. | .. | * | .. | .. |
| Cypraea granti, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| Galeodea monilifera, Noet. | .. | .. | .. | .. | * | .. |
| Ficula theobaldi, Noet. | .. | .. | .. | .. | .. | * |
| Pyrula bucephala, Lamarck. | .. | .. | .. | .. | .. | * |
| „ pseudobucephala, Noet. | .. | .. | .. | .. | .. | * |
| Oliva rufula, Duclos | .. | * | .. | * | * | .. |
| Genota irravadaca, Noet. | .. | .. | .. | .. | .. | * |
| Clavatula fulminata, Kiener, sp. | .. | .. | .. | .. | .. | * |
| „ protonodifera, Noet. | .. | .. | .. | .. | .. | * |
| Conus avaensis, Noet. | * | * | * | * | * | .. |
| Callianassa birmanica, Noet. | .. | .. | .. | * | * | .. |
| *Lamna spallanzanii*, Bonaparte | .. | .. | .. | .. | .. | * |
| Carcharias gangeticus, Müller & Henle | .. | .. | .. | .. | .. | * |
| Number of forms common to each zone | 6 | 10 | 8 | 16 | 14 | 22 |

## Zone of *Meiocardia metavulgaris* (Singu).

| — | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototort. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Paracyathus caeruleus, Duncan | .. | .. | .. | * | * | .. |
| Pecten irravadicus, Noet. | .. | .. | .. | .. | .. | * |
| Avicula suessiana, Noet. | .. | .. | .. | .. | .. | * |
| Vulsella lingua-tigris Noet. | .. | .. | .. | * | .. | .. |

## Zone of *Meiocardia metavulgaris* (Singu)—*contd.*

| — | Zone of cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototort. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Modiola buddhaica, Noet. | .. | .. | .. | .. | .. | * |
| Lithodomus sp. | .. | .. | .. | .. | .. | * |
| Arca bistrigata, Dunker | .. | .. | .. | .. | .. | * |
| Nucula alcocki, Noet. | .. | .. | .. | .. | * | .. |
| Leda birmanica, Noet. | .. | .. | .. | .. | .. | * |
| Cardita scabrosa, Noet. | .. | .. | .. | .. | .. | * |
| „ tjidamarensis, K. Martin | .. | .. | .. | .. | .. | * |
| „ viquesneli, d'Arch. & Haime | .. | * | .. | * | .. | .. |
| „ cf. mutabilis, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| Crassatella dieneri, Noet. | .. | .. | .. | .. | .. | * |
| Meiocardia metavulgaris, Noet. | .. | .. | .. | .. | .. | * |
| Dione protolilacina, Noet. | * | .. | * | * | * | .. |
| „ protophilippinarum, Noet. | * | * | * | * | * | .. |
| Tellina grimesi, Noet. | * | * | * | * | * | .. |
| Gari kingi, Noet. | .. | .. | .. | .. | .. | * |
| Corbula rugosa, Sowerby | .. | .. | .. | .. | .. | * |
| Calliostoma blanfordi, Noet. | .. | .. | .. | .. | .. | * |
| Turcica protomonilifera, Noet. | .. | .. | .. | .. | * | .. |
| Basilissa lorioliana, Noet. | .. | .. | .. | .. | * | .. |
| Solarium maximum, Philippi | .. | .. | .. | * | * | .. |
| Cypraea granti, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| Galeodea monilifera, Noet. | .. | .. | .. | .. | * | .. |
| Ficula theobaldi, Noet. | .. | .. | .. | .. | .. | * |
| Conus avaensis, Noet. | * | * | * | * | * | .. |
| Balanus tintinnabulum, Linné | * | * | .. | * | * | .. |
| Callianassa birmanica, Noet. | .. | .. | .. | * | * | .. |
| *Lamna spallanzanii*, Bonaparte | .. | .. | .. | .. | .. | * |
| Carcharias gangeticus, Müller & Henle | .. | .. | .. | .. | .. | * |
| Number of forms common to each zone | 5 | 5 | 4 | 10 | 12 | 18 |

## Zone of *Dione dubiosa* (Singu & Yenangyat).

| — | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototort. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Lucina d'archiaciana, Noet. | .. | .. | .. | .. | .. | * |
| Dione dubiosa, Noet. | .. | .. | .. | .. | .. | * |
| Corbula prototruncata, Noet. | .. | .. | .. | .. | * | .. |
| Scalaria leptopleurata, Noet. | .. | .. | .. | .. | .. | * |

## Zone of *Paracyathus caeruleus* (Yenangyat).

| — | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototortuosum. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Paracyathus caeruleus, Duncan | .. | .. | .. | * | * | .. |
| Eupsammia regalis, Alcock | .. | .. | .. | .. | .. | * |
| Pecten irravadicus, Noet. | .. | .. | .. | .. | .. | * |
| Arca bistrigata, Dunker | .. | .. | .. | .. | * | * |
| Nucula alcocki, Noet. | .. | * | .. | .. | * | .. |
| Lucina pagana, Noet. | .. | .. | .. | * | .. | .. |
| Dione amygdaloides, Noet. | .. | * | * | * | * | .. |
| ,, protophilippinarum, Noet. | * | * | * | * | * | .. |
| Tellina hilli, Noet. | .. | * | * | * | * | .. |
| Gari kingi, Noet. | .. | .. | .. | .. | .. | * |
| Solen sp. | .. | .. | * | .. | .. | .. |
| Calliostoma blanfordi, Noet. | .. | .. | .. | .. | .. | * |
| Solarium maximum, Philippi | .. | .. | .. | * | * | .. |
| Torinia buddha, Noet. | .. | .. | .. | .. | .. | * |
| Turritella affiniformis, Noet. | .. | .. | .. | .. | .. | * |
| Siliquaria, spec. 1, Noet. | .. | .. | .. | .. | .. | * |
| Calyptraca rugosa, Noet. | .. | * | * | .. | * | .. |

## Zone of *Paracyathus caeruleus* (Yenangyat)—*contd.*

| — | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototortuosum. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Natica callosa, Sowerby | * | * | .. | * | * | .. |
| ,, obscura, Sowerby | * | * | * | * | * | .. |
| Sigaretus neritoideus, Linné | * | .. | .. | * | .. | .. |
| Cypraea granti, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| Trivia smithi, K. Martin | .. | .. | .. | .. | .. | * |
| Ficula theobaldi, Noet. | .. | .. | .. | .. | .. | * |
| Triton pardalis, Noet. | .. | .. | .. | .. | * | .. |
| ,, neastriatulus, Noet. | . | .. | .. | .. | * | .. |
| Ranella prototuberculāris, Noet. | .. | .. | .. | * | * | .. |
| Fusus seminudus, Noet. | .. | .. | .. | .. | .. | * |
| Fasciolaria nodulosa, Sowerby | .. | .. | .. | .. | .. | * |
| Murex (?) tchihatcheffi, d'Arch. & H. | .. | .. | .. | .. | .. | * |
| Voluta dentata, Sowerby | .. | .. | .. | .. | .. | * |
| Oliva rufula, Duclos | .. | * | .. | * | * | .. |
| Cancellaria pseudocancellata, Noet. | .. | .. | .. | .. | .. | * |
| ,, davidsoni, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| ,, martiniana, Noet. | .. | .. | .. | .. | .. | * |
| Terebrum sp. | .. | .. | .. | .. | .. | * |
| Surcula feddeni, Noet. | .. | .. | .. | .. | * | .. |
| Drillia yenanensis, Noet. | .. | .. | .. | .. | .. | * |
| Conus malaccanus, Hwas | .. | .. | .. | .. | .. | * |
| ,, protofurvus, Noet. | .. | .. | .. | * | .. | .. |
| ,, galensis, Noet. | .. | .. | .. | .. | .. | * |
| Balanus tintinnabulum, Linné | * | * | .. | * | * | .. |
| Callianassa birmanica, Noet. | .. | .. | .. | * | * | .. |
| Myliobates sp. | .. | .. | .. | .. | .. | * |
| *Lamna spallanzanii*, Bonaparte | .. | .. | .. | .. | .. | * |
| Carcharias gangeticus, Müller & H. | .. | .. | .. | .. | .. | * |
| Otolithus sp. | .. | .. | .. | .. | .. | * |
| Number of forms common to each zone | 5 | 8 | 6 | 14 | 16 | 26 |

## Zone of *Cancellaria martiniana* (Minbu).

| | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototortuosum. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Paracyathus caeruleus, Duncan . . . | .. | .. | .. | * | * | .. |
| Pecten irravadicus, Noet. . . . . | .. | .. | .. | .. | .. | * |
| Pinna sp. . . . . . . . . | .. | .. | * | . | .. | .. |
| Arca bistrigata, Dunker . . . . | .. | .. | .. | .. | .. | * |
| Nucula alcocki, Noet. . . . . | .. | .. | .. | .. | * | .. |
| Dione dubiosa, Noet. . . . . . | .. | .. | .. | .. | .. | * |
| ,, protophilippinarum, Noet. . . | * | * | * | * | * | .. |
| Tellina hilli, Noet. . . . . . | .. | * | * | * | * | .. |
| Gari kingi, Noet. . . . . . | .. | .. | .. | .. | .. | * |
| Corbula prototruncata, Noet. . . . | .. | .. | .. | .. | * | .. |
| Calliostoma blanfordi, Noet. . . . | .. | .. | .. | .. | .. | * |
| Solarium maximum, Philippi . . . | .. | .. | .. | * | * | .. |
| Torinia protodorsuosa, Noet. . . . | .. | .. | .. | .. | * | .. |
| ,, buddha, Noet. . . . . . | .. | .. | .. | .. | .. | * |
| Discohelix minuta, Noet. . . . . | .. | .. | .. | .. | .. | * |
| Scalaria spathica, Noet. . . . . | .. | .. | .. | .. | .. | * |
| ,, birmanica, Noet. . . . | .. | .. | .. | * | .. | .. |
| ,, irregularis, Noet. . . . | .. | .. | .. | .. | .. | * |
| Turritella affiniformis, Noet. . . . | .. | .. | .. | .. | .. | * |
| Calyptraea rugosa, Noet. . . . . | .. | * | * | .. | * | .. |
| Natica callosa, Sowerby . . . . | * | * | .. | * | * | .. |
| ,, obscura, Sowerby . . . . | * | * | * | * | * | .. |
| Cypraea granti, d'Arch. & Haime . . | .. | .. | .. | .. | .. | * |
| Cassis d'archiaca, Noet. . . . . | .. | .. | .. | .. | .. | * |
| Semicassis protojaponica, Noet. . . . | .. | .. | .. | .. | .. | * |
| Oniscidia minbuensis, Noet. . . . | .. | .. | .. | .. | .. | * |
| Ficula theobaldi, Noet. . . . . | .. | .. | .. | .. | .. | * |
| Triton pardalis, Noet. . . . . | .. | .. | .. | .. | * | .. |
| Ranella prototubercularis, Noet. . . | .. | .. | .. | * | * | .. |
| Fusus seminudus, Noet. . . . . | .. | .. | .. | .. | .. | * |
| Fasciolaria nodulosa, Sowerby . . . | .. | .. | .. | .. | .. | * |
| Murex arrakanensis, Noet. . . . | .. | .. | .. | .. | .. | * |

Zone of *Cancellaria martiniana* (Minbu)—*contd.*

| | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Paral. prototortuosum. | Zone of Arca theobaldi. | Not known in the preceding zones. |
|---|---|---|---|---|---|---|
| Volvaria birmanica, Noet. | .. | .. | .. | .. | .. | * |
| Voluta ringens, Noet. | .. | .. | .. | .. | .. | * |
| ,, dentata, Sowerby | .. | .. | .. | .. | .. | * |
| Oliva rufula, Duclos | .. | * | .. | * | * | .. |
| Cancellaria davidsoni, d'Arch. & Haime | .. | .. | .. | .. | .. | * |
| ,, martiniana, Noet | .. | .. | .. | .. | .. | * |
| Terebrum smithi, K. Martin | .. | .. | .. | .. | .. | * |
| Subula sp. | * | * | .. | .. | .. | .. |
| Surcula feddeni, Noet. | .. | .. | .. | .. | * | .. |
| Genota irravadica, Noet. | .. | .. | .. | .. | .. | * |
| Clavatula protonodifera, Noet. | ... | .. | .. | .. | .. | * |
| Drillia protointerrupta, Noet. | .. | .. | .. | .. | * | .. |
| Conus malaccanus, Hwas | .. | .. | .. | .. | .. | * |
| Balanus tintinnabulum, Linné | * | * | .. | * | * | .. |
| Callianassa birmanica, Noet. | .. | .. | .. | * | * | .. |
| Cancer sp. | .. | .. | .. | .. | .. | * |
| Myliobates sp. | .. | .. | .. | .. | .. | * |
| Carcharias gangeticus, Müller & H. | .. | .. | .. | .. | .. | * |
| Galeocerdo sp. | .. | .. | .. | .. | .. | * |
| *Lamna spallanzanii*, Bonaparte | .. | .. | .. | .. | .. | * |
| Number of forms common to each zone | 5 | 8 | 5 | 11 | 17 | 32 |

**Fauna of the oilfields cannot be correlated with any zone below the Kama clays.**

From the above tables it is at once evident that the fauna from the three oilfields, Singu, Yenangyat, and Minbu, is different from that of any of the zones in the Upper or Lower Prome series or Kama clays (which represent the whole of the fossiliferous portion of the Pegu system in Lower Burma). Certainly they do not indicate a position between the zones of *Arca theobaldi* and *Cytherea erycina*.

**Fauna of the oilfields younger than that of *Arca theobaldi* zone (base of Kama clays).**

From the dissimilarity of their fauna with that of the Nummulitic series in Burma, and from the number of living species which they contain which are not known in any of the Pegu rocks of Lower Burma, it is fair to assume that they occupy a higher position in the stratigraphical scale than the zone of *Arca theobaldi* (situated at the base of the Kama clays). This view receives confirmation from the form *Lamna spallanzanii*, Bonaparte, which occurs in each of the three fields. It is synonymous with *Oxyrhina spallanzanii*, Bonaparte, and also with *Oxyrhina gomphodon*, Müller & Henle, and has been found to have the restricted range of Pliocene to recent times.[1] It is possible that the rocks in which it occurs may be high in the Miocene system, but it certainly proves that these rocks in which it occurs occupy a position high above that occupied by the zone of *Arca theobaldi* (base of the Kama clays).

**Fossils from Yenangyaung from zone identified by Noetling as being *Cytherea erycina* zone.**

In addition to the evidence given above there is that of the marine fossils found in the Yenangyaung oilfield by Mr. Pascoe and discussed by him in the *Records of the Geological Survey of India*, Vol. XXXVI, pp. 135—142. These fossils are of special interest; for, if Noetling is correct, they come from the horizon of the zone of *Cytherea erycina*, that is, from the base of his Yenangyaungian division. The vertical range of these forms through the known zones is given in the following tables, and I think that no one would say that they correspond to the zone of *Cytherea erycina*. The contention that the horizon from which these forms were collected is situated above the zone of *Arca theobaldi* is again supported.

| —— | In Lower Prome series. | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Parallel. protortuosum. | Zone of Arca theobald. | Not known in any of these zones. |
|---|---|---|---|---|---|---|---|
| Rotalia sp. | .. | .. | .. | .. | .. | .. | * |
| Dendrophillia sp. | .. | .. | .. | .. | .. | .. | * |
| Arca theobaldi | .. | .. | .. | .. | .. | * | .. |
| „ myaensis | .. | .. | .. | .. | .. | * | .. |

[1] Beiträge zur Kenntniss der Gattung Oxyrhina, C. R. Eastman, *Palæontographica*, XLI, 1894, pp. 189—191.

| — | In Lower Prome series. | Zone of Cytherea erycina. | Zone of Aricia humerosa. | Zone of Pholas orientalis. | Zone of Parallel. prototortuosum. | Zone of Arca theobaldi. | Not known in any of these zones. |
|---|---|---|---|---|---|---|---|
| Arca bistrigata | .. | .. | .. | .. | .. | .. | * |
| Nucula alcocki | .. | .. | .. | .. | .. | * | .. |
| Leda virgo | .. | .. | .. | .. | .. | * | .. |
| Cardita protovariegata | .. | * | .. | .. | * | .. | .. |
| " visquesneli | .. | .. | * | .. | * | .. | .. |
| Lucina neasquamosa | .. | .. | .. | .. | * | .. | .. |
| Venus protoflexuosa | .. | .. | .. | * | .. | .. | .. |
| " granosa | .. | .. | .. | .. | .. | .. | * |
| Dione protophilippinarum | .. | * | * | * | * | * | .. |
| " protolilacina | .. | * | .. | * | * | * | .. |
| " dubiosa | .. | .. | .. | .. | .. | .. | * |
| " (arrakanensis) | .. | .. | .. | .. | * | .. | .. |
| Tapes protolirata | .. | .. | .. | .. | .. | .. | * |
| Dorsinia protojuvenilis | .. | * | * | .. | * | .. | .. |
| Corbula prototruncata | .. | .. | .. | .. | .. | * | .. |
| Basilissa loriolìana | .. | .. | .. | .. | .. | * | .. |
| Solarium maximum | .. | .. | .. | .. | * | * | .. |
| Turritella simplex | * | .. | .. | .. | * | * | .. |
| " acuticarinata | * | .. | .. | .. | * | * | .. |
| " lydekkeri | .. | .. | .. | .. | * | .. | .. |
| Calyptræa rugosa | .. | .. | * | * | .. | * | .. |
| Natica obscura | .. | * | * | * | * | * | .. |
| " gracilior | .. | .. | .. | .. | * | .. | .. |
| Sigaretus neritoideus | .. | * | .. | .. | * | .. | .. |
| Oliva (Strephona) rufula | .. | .. | * | .. | * | . | .. |
| Strioterebrum unicinctum | .. | * | .. | .. | .. | * | .. |
| " sp. | .. | .. | .. | .. | .. | * | .. |
| Terebrum smithi | .. | .. | .. | .. | .. | .. | * |
| Pleurotoma karenaica | .. | .. | .. | .. | .. | * | .. |
| Clavatula munga (?) | .. | .. | .. | .. | * | .. | .. |
| Balanus tintinnabulum | .. | * | * | .. | * | * | .. |
| Carcharias (Prionodon) gangeticus | .. | .. | .. | .. | .. | .. | * |
| Twingonia | .. | .. | .. | * | .. | .. | * |
| Number of forms common to the zones | 2 | 7 | 7 | 5 | 17 | 18 | 9 |

**Fossil evidence supports view that the Pegu rocks of the oilfields are upper development of the Kama clays.**

The fossil evidence, therefore, instead of proving that the shale series exposed in the various oilfields are the equivalents of the Upper and Lower Prome series, indicates that they are the upper development of the Kama clays and in this corroborates the view expressed in the previous pages. It also seems probable from the foregoing figures that the zone of *Aricia humerosa* is situated above the zone of *Pholas orientalis*.

## Summary.

The points given in the preceding paper which are contrary to the views held hitherto are the following:—

1. The oligocene age of the Upper and Lower Prome series and Sitsayan shales
2. The great thickness of Kama clays whose existence has hitherto never been suspected, giving the Kama clays a development ranging from Burdigalian to Pontian (from the base of the Lower Miocene to the Upper Miocene).
3. Noetling's correlation of the oilfields with Theobald's divisions in Lower Burma is contradicted by the fossil evidence
4. The indications that the Pegu rocks exposed in the oilfields are the upper development of the Kama clays, and that therefore they resemble in structure the exposure at Padaukpin.
5. The main oil-bearing strata seem to be the Kama clays (see the previous paper)
6. The magnitude of the unconformity between the Pegu and Irrawaddy systems, although it is hard to distinguish in any individual section.

## Prospects of Oil.

*Padaukpin and Banbyin.*—I have already discussed these rocks in detail, and although there is a much greater thickness of oil-bearing strata here than in any of the localities discussed in the